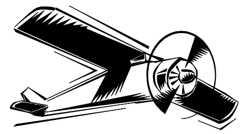


PRINCIPLES OF FLIGHT

INTRODUCTION

Gliders

The glider, which was an early step to modern airplanes, is one type of a heavier-than-air aircraft that usually has no engine (although some gliders may have a small auxiliary engine). In regard to the principles of flight, the forward and downward motion of a glider is the result of gravity while airflow over stationary wings is what produces lift.

To launch a glider into the air, the glider is usually pulled by either another airplane, an automobile, or by a winch that is positioned on the ground. Once airborne, a glider usually remains in the air from one to five hours, although flights over seventy hours have been recorded.

When discussing the early history of gliders, men such as Sir George Cayley, Otto Lilienthal, Octave Chanute, and Percy S. Pilcher are well known for their contributions to the design, development and improvement of the glider. In 1809 Sir George Cayley built and flew the first full-sized, unmanned glider, and later in 1853, Cayley was the first to launch a glider that could support a human.

Otto Lilienthal designed and built gliders from 1891 to 1896. He controlled his glider by shifting his weight as he flew. Lilienthal was able to turn his glider while in flight. Lilienthal died August 9, 1896 as a result of a crash in one of his own gliders. Octave Chanute and Percy S. Pilcher continued their own development and improvement of the glider. Like Lilienthal, Pilcher also died as a result of crashing his glider.

Gliders have been used for several different purposes over the last 100 years or so. For example, during World War II, gliders were used to move supplies and artillery, as well as to carry and relocate soldiers. Today gliders are used primarily for sport, recreation and enjoyment.

Powered Flight

Wilbur and Orville Wright, two bicycle makers from Dayton, Ohio, changed the world with their invention. They made themselves expert engineers, aerodynamicists, and pilots. They set out calmly and deliberately to master the control of gliders in flight, before committing themselves to embarking upon a powered flying machine. They developed the method of twisting the wings (later termed "wing-warping") to provide control in the roll axis. From 1900 to 1902, they built three biplane gliders that they tested at the Kill Devil sand dunes south of Kitty Hawk, North Carolina. Each of these gliders had a forward elevator and wing warping capability. The most important of these gliders was the third glider, built in 1902, which was equipped with twin fixed rear fins. The Wright brothers later exchanged the twin rear fins for a single movable rear rudder in order to counteract the warp-drag of the wings that tended to spin the glider around its vertical axis and send it out of control. The rear rudder also enabled the pilot to achieve banked turns, and also to

level up the wings if they were gusted out of the horizontal, again significantly lessening the danger of the aircraft spinning out of control. For the first time in history, the problem of full three-axis control was effectively solved. All flight control of modern aircraft can be traced back to this properly controllable glider Number 3 of 1902. Early in 1906, the Wrights' patent incorporating these features was widely published in Europe and America.

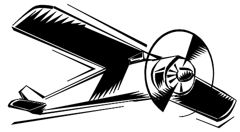
In 1903 the Wrights built their first powered airplane based on the 1902 glider. This machine not only incorporated three-axis control, but a 12 hp gasoline engine and two propellers. The propellers were geared down in relation to the engine revolutions to provide optimum thrust.

On December 17, 1903, at Kill Devil Hills, North Carolina, from level ground, the Wrights made the world's first powered, sustained, and controlled flights in a heavier-than-air flying machine. The first of four flights had Orville at the controls, lasted 12 seconds, and covered 120 feet in distance. The last flight that day had Wilbur Wright as the pilot and lasted 59 seconds and covered 852 feet.

During 1904 and 1905, the Wrights returned to Dayton, Ohio and began flying at Huffman Prairie, now part of Wright-Patterson Air Force Base. In the second and third powered Flyers, the brothers strived to perfect their invention. By 1905, they solved the remaining aerodynamic problems and could bank, turn, circle and perform figure eights, all with ease and safety, while staying in the air for over 30 minutes at a time. This Wright Flyer III was the world's first fully practical powered airplane.

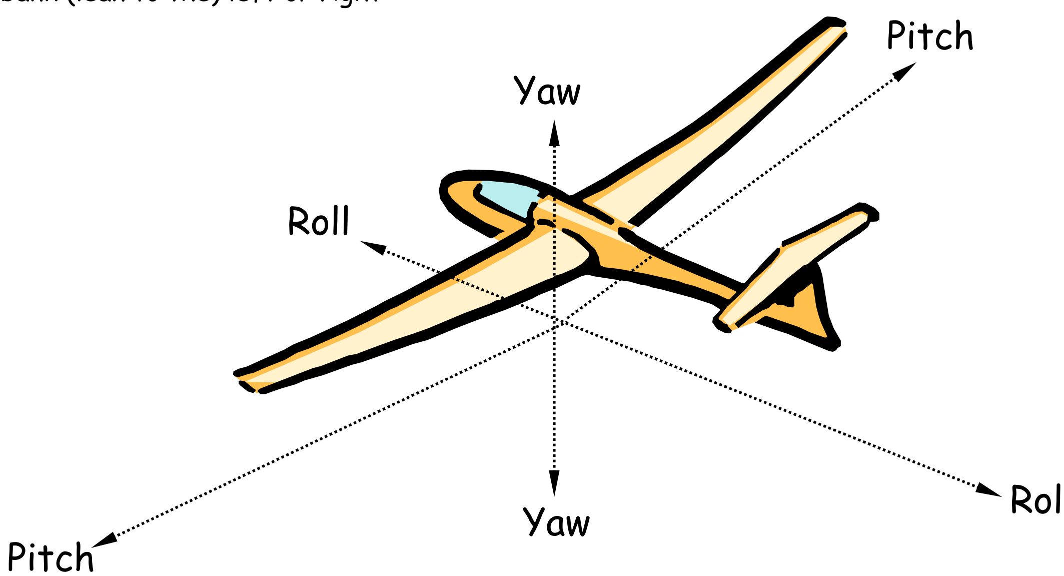
How An Airplane Flies

1. There are four forces that affect an airplane's actions: lift, gravity, thrust, and drag.
2. Two of the forces, lift and thrust, help an airplane go up and stay up in the air.
3. The other two forces, gravity and drag, work against an airplane from getting up or staying up.
4. Gravity pulls a plane down and works against lift which pulls it up.
5. Drag slows a plane down and works against thrust, which moves it forward.
6. Lift occurs when air passes over and under a wing. Because of the wing's shape the air pressure over the top of the wing is less than the pressure underneath the wing. The stronger air pressure under the wing lifts it up.
7. Thrust is made by a propeller, a jet engine, or a rocket motor. It moves the airplane forward.
8. Drag is produced when air pushes against the airplane as the airplane moves forward through the air.
9. An airplane will fly if the forces of lift and thrust are greater than the forces of gravity and drag. If the forces of drag and gravity are greater than lift and thrust, the airplane will not fly.
10. Once an airplane is in the air, it has to be controlled.
11. The pilot moves levers and knobs inside the airplane to make it climb, dive, slow down, speed up and turn.
12. The throttle increases or decreases fuel to the engine to make the plane go faster or slower.



13. When a pilot pushes the throttle forward, the airplane goes faster. Air passes over its wings faster. This increases lift and the plane climbs.
14. When a pilot pulls the throttle back, the airplane goes slower. Air passing over its wing slows down. This decreases lift and the plane goes down.
15. The control column, a wheel or stick, can be moved forward, back, right or left. It can make an airplane tilt up, down, or sideways.
16. Pedals on the floor can be pushed to move a rudder on the tail. The rudder helps a pilot make a smooth turn.
17. When a pilot pulls back on the control column, the elevators go up. This tilts the airplane's nose up.
18. When a pilot pushes the control column forward, the nose goes down.
19. To turn, a pilot must use four controls.
20. When the control column is moved to the right, the right aileron goes up and the left aileron goes down. The plane begins to roll to the right. To make this turn smooth and to keep the airplane from falling, the pilot pushes the throttle forward for more speed. The pilot also presses down on the right rudder pedal and pulls back on the control column.
21. To turn left, the pilot moves the column left and pushes down the left rudder pedal. The pilot pushes the throttle forward for more speed and pulls back the control column to help make the turn smooth. Because airplanes are often in a position where "up" and "down" are meaningless words, there are three special terms used to describe an airplane's movements.

    Yaw: movements to the left or right
    Pitch: movements up or down
    Roll: bank (lean to the) left or right



An excellent resource for text and illustrations is the Beginner's Guide to Aerodynamics through the NASA Glenn Research Center at www.grc.nasa.gov/WWW/k-12/airplane/index,html

Wings That Spin

Grade Level: K-1 **Subject Area:** Science

Time Required
Preparation: 20 minutes
Activity: 60-90 minutes

National Standards Correlation
Science (grades K-4)
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Physical Science Standard: Properties of objects and materials.
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.
- Earth and Space Standard: Objects in the sky.

Objectives
Students will:
- Build a paper blimp and a gyrocopter
- Successfully fly the blimp and gyrocopter
- Make observations
- Change variables and record data
- Discuss data

Background
The idea of a rotating wing, rather than a fixed wing, was the basis of Leonardo da Vinci's concept of a helicopter. The idea is straight from nature. Watch a maple seed as it drops from a tree -- it spins! When inventors first tried to use rotating wings to fly, there were several problems. In a spinning aircraft, the pilot would also rotate. When plans were made for the pilot to sit on a platform and use muscle power to turn the wings, the platform would rotate in the opposite direction to the wings. The first successful rotating wing was the autogiro, and later the helicopter as developed by Igor Sikorsky.

In addition to illustrating the effect of gravity on a flying object, this activity will also show how changing certain variables can affect flight.

Materials
- a piece of paper (1" x $8\frac{1}{2}$") for each flying blimp
- a piece of paper ($1\frac{1}{2}$" x $8\frac{1}{2}$") for each gyrocopter
- scissors
- paper clips (for added weight)
- blimp and gyrocopter patterns (see Patterns Section at end of Curriculum Guide)

Safety Instructions: *Use common sense precautions.*

Procedure

A. Warm-up

1. Give a short lesson on the four forces of flight, and explain how airplanes and helicopters fly.
2. Review the organization and recording of data.

B. Activity I

1. Construct the paper blimp by using the master pattern sheet (see "Patterns" section). Cut on the solid black lines. Bend the paper (but do not crease it) so the two cuts fit into each other.
2. To fly the paper blimp, hold it high above your head and drop it. As it falls it will start spinning and look like a blimp. Spinning makes it stable in the air.
3. Determine if the blimp spins clockwise or counter-clockwise.

Activity II

1. Construct the paper gyrocopter using the master pattern sheet. Cut on the solid black lines. Fold on the dotted line at "A" so the fold does not cover the name. Fold on the dotted line at "B" so the fold does not cover the name. Fold on the dotted line at "C" so the fold does not cover the name. Now, fold on the dotted line at "D" so the fold does not cover the name and fold on the dotted line at "E" so the fold covers the name.
2. Bring the two "wings" up so they are perpendicular to the ABC section.
3. To fly the paper gyrocopter, hold it over your head and drop it. It will glide to the floor spinning.
4. Determine if the paper gyrocopter spins clockwise or counter-clockwise.
5. Now fold "D" so it covers the name and "E" so it does not cover the name.
6. Determine if it spins clockwise or counter-clockwise.
7. Add a paper clip near the fold at "C."
8. Write and record data and observations.

C. Wrap-up

1. Share the data and discuss the variables.

Assessment/Evaluation

Students should be evaluated on accuracy of observations and collection and organization of accurate data.

Extensions

1. Undo the paper blimp and re-attach, bending in the opposite direction of the initial trial (the blimp will spin in the opposite direction, just as the gyrocopter).
2. Drop the gyrocopters from various heights and observe.

Resources/References

Francis, Neil. *Super Flyers.* Reading, Massachusetts: Addison-Wesley Publishing Company, Inc., 1988.

Paper Dart Airplane

Grade Level: 3-4 **Subject Area:** Science

Time Required
Preparation: 1 hour
Activity: 2-4 hours

National Standard Correlation
Science (grades K-4)
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Physical Science Standard: Properties of objects and materials.
- Science in Personal and Social Perspectives: Science in technology in local challenges.

Summary
Students will construct a paper airplane called the "Paper Dart". The paper airplane will be used as a model to identify and discuss various principles of flight (such as lift, drag, gravity, air pressure, weight, thrust, airfoil and friction). The students will experiment with different aileron configurations and determine how these changes affect the flight of the paper dart.

Objectives
Students will:
- Build a paper dart following written and verbal instructions
- Investigate how various alterations to the ailerons on the paper dart affect the distance and path of flight
- Reach a conclusion about the most successful placement of the ailerons to achieve maximum flight distance
- Measure and record distance flown by paper dart
- Make a bar graph to represent distances flown by the paper dart
- Reinforce knowledge and understanding of previously introduced terminology

Background
See Principles of Flight Introduction.

Materials
- paper (8½" x 11")
- paper clips
- tape
- scissors
- tape measure (metric or standard)
- notebook paper
- pencil and colored pencils
- graph paper

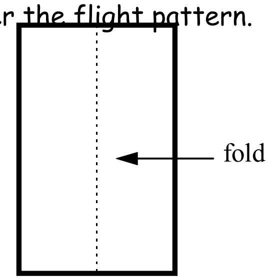
* Paper Dart pattern (See Patterns section at end of this Curriculum Guide)

Safety Instructions: *Do not fly paper gliders directly at another person because the pointed tip could cause injury. Use caution when flying the paper airplanes. Create a single direction flight zone. Be sure that students stop flying their airplanes when other students are retrieving airplanes that have already landed.*

Procedure

A. Warm Up

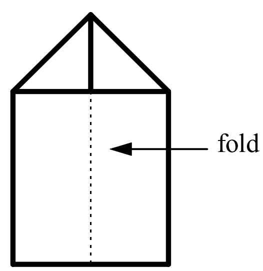
1. Explain the function of the wing on an airplane. The best wing has a curve along the upper surface and a flatter lower surface. The wing on the dart is curved toward the top and flatter on the bottom. The ailerons at the back of the paper airplane will alter the flight pattern.
2. Review the four forces of flight (lift, drag, thrust, gravity).
3. Review measuring skills (using a tape measure).



B. Activity I

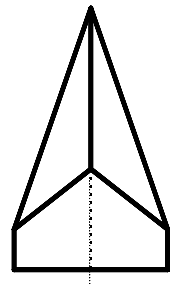
1. Using the Paper Dart airplane pattern, construct a paper airplane using the following instructions:

a. Fold the pattern in half lengthwise and open.

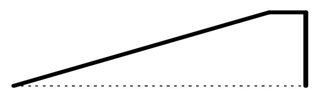


b. Fold down the top two corners of the paper so they meet together at the center line. Make folds as neatly as possible. Rub with the side of a pencil to make the fold nice and crisp.

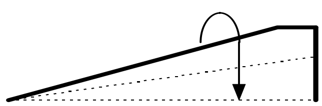
c. Fold the entire right-hand top edge to the center line. Now fold the entire left-hand top edge to the center line. The two folds will meet in the middle.

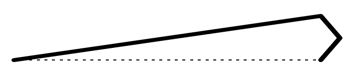


d. Fold plane in half along the center line.

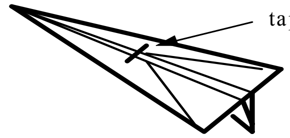


e. Now take one of the open edges and fold it back to the "folded" center line.





f. Turn the paper over and repeat. Gently pull up on the wings and tape them into place.



g. To make the ailerons, cut on the solid lines and fold on the dotted lines, as indicated on the master pattern.

2. Go to a large indoor area (gymnasium) and practice flying the paper dart airplanes.
3. Using masking tape, mark a line for the students to stand behind when flying their darts.

4. Students will fly their darts a total of four times, each time with a different aileron configuration.

1st flight - no ailerons
2nd flight - both ailerons up
3rd flight - both ailerons down
4th flight - one aileron up and one aileron down

5. Measure the distance flown during each flight. Note: You may want to mark the gym floor (with masking tape) at 1 meter intervals to make it easier for students to measure.
6. Record distance flown during each flight on the Dart Chart.
7. Students will determine which aileron configuration provided their paper dart the longest flight distance.
8. Use the aileron configuration that provided the longest flight, to now accomplish Activity II.

Activity II

1. Students will fly their paper dart (with aileron configuration from Activity I) a total of 5 times.
2. Measure and record the distance flown during each of the 5 flights.
3. Make a bar graph to show the five flights.

C. Wrap Up

1. Have students take time to compare their results with other students. Discuss the results.

Assessment/Evaluation

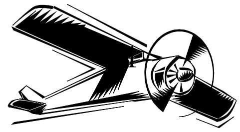
Students can be evaluated by teacher observation of students' participation in the activity. Evaluate graphs for accuracy.

Extensions

1. Using the bar graph, visually and mathematically determine the average distance flown by the paper dart.
2. After a brief discussion of the meaning of "controlled experiment," have students work in pairs to set up a controlled experiment using the paper dart design, but changing one variable. Variables to change could include:

- material used in making the dart (i.e. aluminum foil, heavy paper, lightweight paper)
- use the paper dart from Activity I, but vary the weight of the glider by adding paper clips
- use different sizes of paper to construct the paper dart

During each controlled experiment, students should fly their darts a set number of times and record their results.



THE DART CHART

FLIGHTS	DISTANCE IN CENTIMETERS
NO ailerons	____________________________cm
Both ailerons UP	____________________________cm
Both ailerons DOWN	____________________________cm
One aileron UP and one DOWN	____________________________cm

CONCLUSION:____

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A Plane Old Time

Grade Level: 4 **Subject Area:** Math

Time Required
Preparation: 5 minutes
Activity: 45 minutes

National Standards Correlation
Mathematics (grades K-4)
- Problem Solving Standard: Build new mathematical knowledge through problem solving.
- Problem Solving Standard: Solve problems that arise in mathematics and other contexts.
- Problem Solving Standard: Apply and adapt a variety of appropriate strategies to solve problems
- Problem Solving Standard: Monitor and reflect on the processes of mathematical problem solving.
- Data Analysis and Probability Standard: Formulate questions that can be addressed with data, and collect, organize, and display relevant data to answer them.
- Data Analysis and Probability Standard: Develop and evaluate inferences and predictions that are based on data.

Summary
Students will preview the supplied chart and answer questions pertaining to chart information.

Objectives
Students will:
- Interpret information from a chart
- Compose a flight plan with the supplied information
- Compare information from various airports

Background
Pilots and Air Traffic Controllers learn numerous concepts as they apply to moving an aircraft from one airport to another. Important is the fact that an aircraft can only hold so much fuel. Making the fuel stretch is very important, as well as knowing how much fuel to put on the airplane to begin with. Mileage and elapsed time are also very important, since running out of fuel is not a very good way to end a flight.

Materials
- Worksheet

Procedure
A. Warm-up
1. Review the operations of math, especially the difference (subtraction).
2. Explain how aircraft move from airport to airport, comparing it to an interstate highway.
3. Explain that a pilot wants to go the most direct way he can to another airport and the consequences if he doesn't.

B. Activity

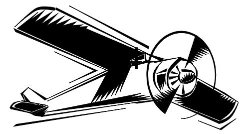
1. Have a student read the brief story at the beginning of the worksheet.
2. Demonstrate the way a pilot or air traffic controller would plan a short trip on an IFR Enroute Chart.
3. Students will use the supplied chart and, by reading the questions, provide the correct information to answer the questions.

Assessment/Evaluation

Check worksheet for correct answers. Have students share their flight plans and compare results.

Resources/References

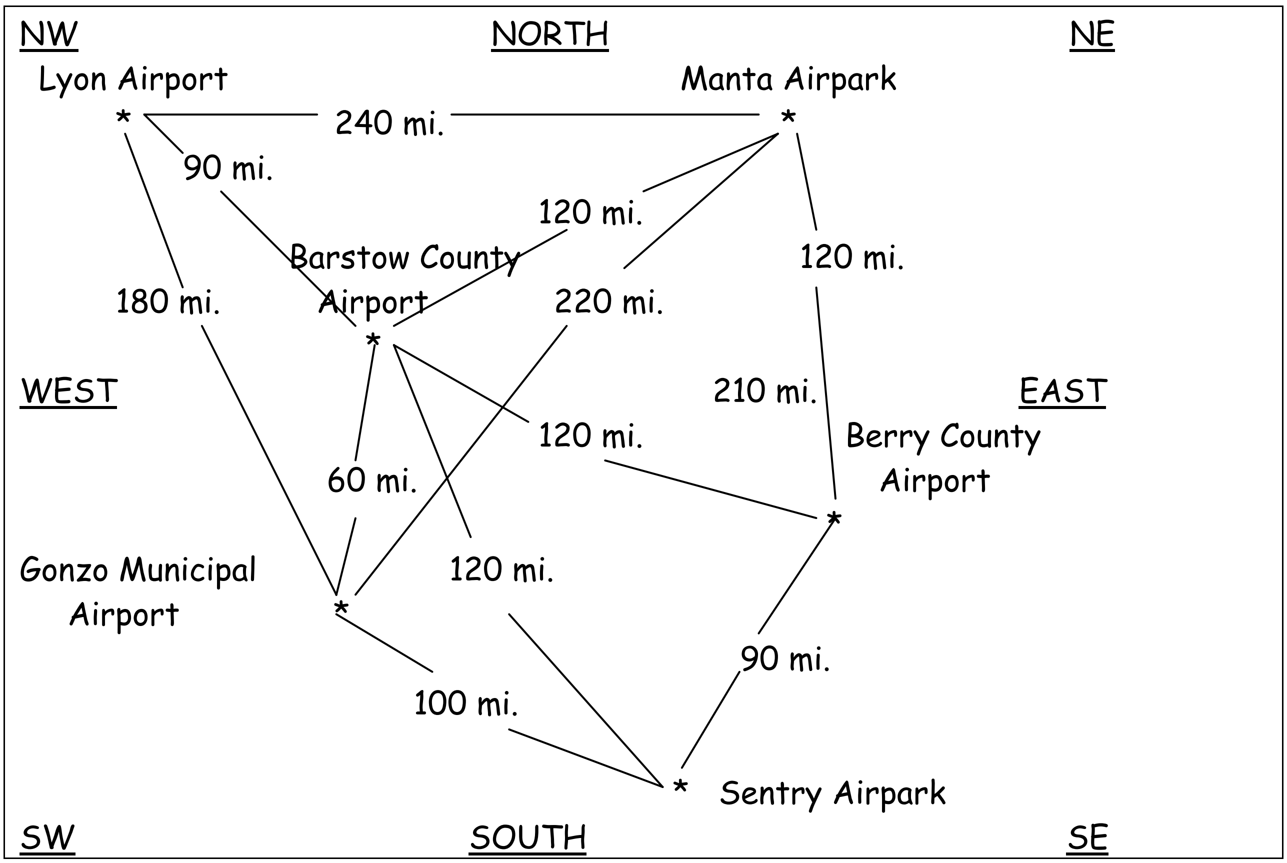
Map worksheet
IFR Enroute Charts, FAA, Washington D.C.



Name__________________

A Plane Old Time

Leah's family owns a small airport in the country named Berry County Airport. They all like to fly and they often make many trips to visit their friends at the neighboring airports. The airplane they fly goes 120 miles per hour and they estimate the length of their trips with this speed.



Use the map above to answer the following questions.

1. Which airport(s) is/are 120 miles from Berry County Airport?

   a. Sentry Airpark only
   b. Barstow County Airport only
   c. Manta Airpark and Barstow County Airport
   d. Sentry Airpark and Barstow County Airport

2. How long is the trip from Berry County Airport to Manta Airpark?
   a. one hour
   b. two hours
   c. three hours
   d. one half hour

3. What are the total number of miles between Berry County, Manta Airpark, and Lyon Airport?
   a. 380 miles
   b. 290 miles
   c. 360 miles
   d. 120 miles

4. What are the total number of miles between Berry County, Sentry Airpark, Gonzo Municipal Airport, Manta Airpark, and back to Berry County?
   a. 460 miles
   b. 530 miles
   c. 430 miles
   d. 550 miles

5. Which airport is located east of Berry County Airport?
   a. Sentry Airpark
   b. Manta Airpark
   c. Gonzo Municipal Airport
   d. No airport is east of Berry

6. Name the airport located in the northwest corner of the map.___________________

7. What is the difference in mileage between Sentry Airpark and Gonzo Municipal Airport, and Barstow County Airport and Manta Airpark?
   a. 240 miles
   b. 20 miles
   c. 220 miles
   d. no difference

8. Which airport is exactly 220 miles from Manta Airpark? _______________________________

9. Design a flight plan that will take you from Berry County Airport and fly exactly 490 miles.

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Which Way Does He Go? Which Way Does She Go?

Grade Level: 4 **Subject Area:** Math

Time Required
Preparation: 5 minutes
Activity: 30 minutes

National Standards Correlation
Mathematics (Grades K-4)
- Problem Solving Standard: Build new mathematical knowledge through problem solving.
- Problem Solving Standard: Solve problems that arise in mathematics and other contexts.
- Problem Solving Standard: Apply and adapt a variety of appropriate strategies to solve problems
- Problem Solving Standard: Monitor and reflect on the processes of mathematical problem solving.
- Data Analysis and Probability Standard: Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.
- Data Analysis and Probability Standard: Develop and evaluate inferences and predictions that are based on data.

Summary
Students will choose the appropriate direction of flight an aircraft would need to fly.

Objectives
Students will:
- Interpret data from a chart
- Choose the correct direction of flight
- Determine the correct direction of flight based on the assigned altitude

Background
Thousands of aircraft fly across the United States each hour of the day. To keep the aircraft from running into each other, a formula was devised to ensure proper separation of aircraft is maintained. Aviation rules require aircraft flying on an instrument flight rules (IFR) flight plan be separated by at least one thousand feet. This formula, as basic as it seems, provides compliance of these rules. Any aircraft flying a heading of north through east (360 degrees through 179 degrees) must be at an odd altitude (3000', 5000', 13000', etc). Any aircraft flying a heading of south through west (180 degrees through 359 degrees) must be at an even altitude (4000', 8000', 16000, etc). This procedure helps both pilots and air traffic controllers in the event a radio outage or some other situation develops that could jeopardize the rule.

Materials
- Worksheet
- 360 degree compass
- pencil

Procedure

A. Warm-up

1. Review the concepts of even and odd numbers.
2. Explain the importance of the formula and its ramifications should these rules be violated.
3. Review concept of 360 degree circle and the applicable cardinal points of the compass. Give students compass for reference.

B. Activity

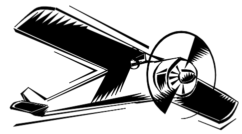
1. Write five or six altitudes on the board. Also draw compass on board.
2. Select a student for each altitude.
3. Have the students determine whether the altitudes are even or odd.
4. Pass out the worksheet and read directions to the students.
5. Allow the students to work on the sheet, completing each question.

Assessment/Evaluation

Students will complete worksheet. Check worksheets for correct answers.

Resources/References

Attached worksheet
FAA Handbook 7110.65



Name________________

Which Way Does He Go? Which Way Does He Go?

Freddy Fighter can't decide which way he wants to go! He wants to fly at a particular altitude, but he's not sure about the correct altitude for his direction of flight! Study the chart below and see if you can answer Freddy's questions.

Altitude For Direction
Of Flight

Compass reading: From 360 degrees to 179 degrees.....Odd Altitudes
(3,000', 5,000', 17,000')
From 180 degrees to 359 degrees....Even Altitudes
(4,000', 8,000', 16,000')

Circle the correct altitude, even or odd, for the direction of flight.

Freddy wants to go on a heading of:

a. 090 degrees   His altitude should be: even/odd

b. 270 degrees   His altitude should be: even/odd

c. 350 degrees   His altitude should be: even/odd

d. 010 degrees   His altitude should be: even/odd

e. 175 degrees   His altitude should be: even/odd

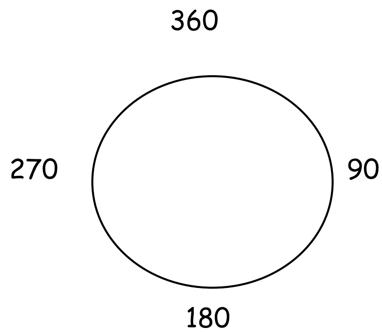
f. 290 degrees   His altitude should be: even/odd

g. 360 degrees   His altitude should be: even/odd

h. 120 degrees   His altitude should be: even/odd

i. 001 degrees   His altitude should be: even/odd

j. 359 degrees   His altitude should be: even/odd



Determine whether the altitudes below are appropriate for the direction of flight.

a. 10,000 ft heading 330 degrees correct / wrong

b. 7,000 ft heading 070 degrees correct/wrong

c. 6,000 ft heading 010 degrees correct/wrong

d. 15,000 ft heading 270 degrees correct/wrong

e. 11,000 ft heading 190 degrees correct/wrong

f. 23,000 ft heading 140 degrees correct/wrong

g. 16,000 ft heading 220 degrees correct/wrong

h. 3,000 ft heading 030 degrees correct/wrong

i. 18,000 ft heading 300 degrees correct/wrong

j. 19,000 ft heading 170 degrees correct/wrong

Time Required:
Preparation: 2 Hours (max.)
Activity: 5 Sessions: 45 minutes per session

National Standards Correlation

Science (grades 5-8)

- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- History and Nature of Science Standard: Nature of Science
- History and Nature of Science Standard: History of Science

Math (grades 3-5)

- Measurement Standard: Apply appropriate techniques, tools, and formulas to determine measurements.

Math (grades 6-8)

- Communication Standard: Use the language of mathematics to express mathematical ideas precisely
- Communication Standard: Communicate their mathematical thinking coherently and clearly to peers, teachers and others.

Summary
Students will be introduced to the four concepts of flight: lift, drag, gravity, and thrust, and make his/her own paper dart airplane to investigate the flight distance and demonstrate an understanding of the forces of flight. The class will analyze and compare their data using line plots and bar graphs created on the computer.

Objectives
Students will:

- Identify and learn the four forces of flight: lift, drag, thrust, and gravity.
- Construct a paper dart airplane as directed.
- Measure the flight duration and length.
- Record and communicate data to create line plots and bar graphs.
- Apply and understand the math concepts of mode, mean, and range.

Background
There are four forces of flight:
Lift – the force that pushes the object up.
Gravity – force that pulls the object down (opposite of lift).
Thrust – the force that pushes the object forward.
Drag – the force that pushes against the object (opposite of thrust).

Materials

- copy paper
- paper airplane models with instructions (dart paper airplane)
- tape
- scissors
- graph paper
- meter sticks or measuring tape
- lined paper (notebook paper)
- chart paper

- markers
- sticky-back notes
- model airplane for demonstration of force of flight concepts

Safety Instructions: Do not fly model planes directly at another person. Use caution when flying the models. Create a single direction flight zone. Students should face launched airplanes and watch carefully. Be sure that students stop flying their airplanes when others are retrieving airplanes that have already landed.

Procedure

A. Warm-up

1. Use a model airplane to demonstrate the principles of flight. Ask the question: "What makes this model fly?"
2. Have the class "Think, Pair, and Share" (Kagan Cooperative Learning Structure). Each student will think to him/her-self an answer to the question. The students will then have 30 seconds to pair up and share his/her answer with the person next to them.
3. Elicit possible answers by calling on pairs to share their ideas.
4. Record student responses on chart paper.

B. Activity I

1. Show the students The Discovery Channel video "Flight".
2. Discuss key concepts on the four forces of flight.
3. Give each student two sheets of notebook paper. Provide verbal instructions as students work in pairs:
   - Hold the papers side by side in front of your face.
   - Gently blow air between the pieces of paper.
   - Observe what happens.
   - Discuss observations.

C. Wrap-up

Preview the next day's activity: building a paper airplane.

D. Warm-up

1. Throw a previously constructed paper airplane "Dart" across the room.
2. Review vocabulary/concepts from Session One. Ask: "What made this paper airplane fly?"

E. Activity II

1. Formally introduce the Four Forces of Flight.
2. Use chart paper or dry erase board to write the definitions of drag, gravity, thrust and lift, and instruct students to copy these terms/definitions into their lab books.
3. Hand out dart paper airplane worksheet.
4. Demonstrate and lead the construction of the paper dart airplane.
5. Review safety instruction with the class.
6. Allow students to practice flying the paper dart. For safety, the students will stand in a single file line to throw their paper darts.

F. Wrap-up

1. Discuss the four forces of flight. (What is the thrust for your plane? What is the drag? What is the resistant force? What is lifting the plane?)

G. Warm-up

1. Lead a short review of Session Two.
2. Have students create a new dart paper airplane to be used for a paper airplane contest.
3. Explain the contest: The students will participate in a contest to measure the distance each plane travels.
4. Each student will predict the distance they think their plane will fly. Record student predictions on a class roster of names.
5. Review safety instruction with the class.

H. Activity IV

The contest can be done in the gym, outside, or in the classroom.

1. Students will be given two attempts to throw their paper airplane. They will measure and record both distances on the class roster next to the predictions.
2. Create a class line plot (numbers line) and allow each student to post their best distance on the line with a sticky-back note.. Make sure they write their name and distance on the note.
3. Instruct students to carefully save their airplane and airplane plans for a future activity.

I. Warm-up

Use the following questions to discuss class results:

1. Whose plane flew the farthest?
2. Whose plane flew the shortest distance?
3. Who came closest to their prediction?

J. Wrap-up

1. Discuss the four forces of flight: lift, drag, thrust, and gravity.
2. Discussion questions:
   - Why did your paper airplane fly well?
   - Why did your paper airplane not fly too well?
   - How can you improve your plane?

K. Activity V

1. Using the line plot, review the concepts of mode, mean and range.
2. Using graph paper, instruct students to create a bar graph showing the results for the entire class.

L. Warm-up

1. Inform students that they will have an opportunity to create another paper airplane, and that they are to be thinking of ways to improve their plane or create a new design.

M. Wrap-up

1. Review the four forces of flight: lift, drag, thrust, and gravity.
2. Have students look at their dart paper airplanes that they used for the contest. Ask: “What improvements could you make to the airplane?”

N. Activity VI

1. The students will have the choice to either improve the dart airplane by constructing a new one, try a new design provided by the teacher, or create an entirely new plane.
2. Give students time to fly their planes. Follow the same procedure for the paper airplane contest.
3. Students record their results, and create a new class line plot. Small groups of children will be asked to find the mode, mean and range of distances.

O. Wrap-up

In a class discussion, discuss why “improvements” to their airplanes were/were not successful.

Evaluation/Assessment

Students should be evaluated on participation, accuracy of calculations, and ability to describe/observe/apply the four forces of flight.

Extensions

1. Write a summary of the results of their paper airplanes flight capabilities.
2. Write a set of directions on how to construct their paper airplane model.
3. Calculate the average distance flown for the class using a calculator.
4. Measure the time the planes are in flight using stopwatches, and create line plots and bar graphs to show the results.
5. Compare and contrast their two planes in a short essay.

Bernoulli’s Lift

Grade Level: 5-6 **Subject Area:** Science

Time Required
Preparation: 30 minutes
Activity: Three 40-minute classes

National Standards Correlation
Science (grades 5-8)
- Physical Science Standard: Motions and forces.
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.
- History and Nature of Science Standard: Nature of science.
- Science in Personal and Social Perspectives Standard: Science and technology in society.

Summary
Students will investigate air pressure and how it is used in flight. The students will work in cooperative groups of 3 –4 students, and use brainstorming sessions and investigations to apply Bernoulli's Principle to the real world. They will construct two styles of airplane wings, and develop an understanding of how airplanes use air pressure to lift them off the ground. Day 1 includes three short activities, Day 2 involves an experiment with air pressure differences and on Day 3 students build models of wings.

Objectives
Students will:
- Differentiate between high and low air pressure.
- Explain the concept of lift.
- Apply Bernoulli's Principle to flight.

Materials
Activity I: (per group)
- small funnel
- ping-pong ball

Activity II: (per group)
- two sheets of notebook paper

Activity III: (per group)
- hair dryer
- ping-pong ball

Activity IV: (per group)
- One long thin 8' plastic bag/tube (a diaper disposal plastic tube cut to 8' length or a commercial "windbag" from a science materials supplier
- meter stick

Activity V: (per group)
- 2 sheets copy paper
- tape
- modeling clay
- 3 drinking straws

- glue
- a 2 foot long section of an 1/8 inch dowel rod

Safety Instructions: Be sure that students do not put straws in their mouths and/or share straws.

Background

Bernoulli's Principle states that when air flows around an object the air pressure changes as the speed of the air changes. When air moves faster over an object it lowers the pressure, and when air moves slower over an object it raises the pressure.

Procedure

A. Warm-up

1. Ask students what they know about the speed of air and air pressure.

B. Activity I - Lift

1. Give each cooperative group a small funnel and a ping-pong ball.
2. Have the students place the ball inside the small funnel. Ask them to turn the funnel over. (The ball will fall to the ground due to the force of gravity.)
3. Have the students place the ball in the small funnel again.
4. Challenge students to keep the ping-pong ball in the funnel for five seconds after turning the funnel over again. Nothing may touch the ball.
5. After an appropriate amount of time, instruct students to turn the funnel upside down.
6. Instruct students to hold the ball in the funnel with their fingers. Then have only one student in each group blow air into the narrow end of the funnel continuously for about ten seconds.
7. While they are blowing air through the funnel have them remove their fingers from the ball.

NOTE: Funnels should be only one student then washed thoroughly for each additional student.

C. Wrap-up

1. Ask students to explain what happened.
2. The ball should have floated in the funnel because the faster moving air on top of the ball has less pressure. The bottom of the ball has more pressure and is holding the ball up.

D. Activity II – Air Pressure

1. Have one student per group hold two sheets of notebook paper about four inches apart in front of his/her mouth. The sheets should hang down so the pages face each other.
2. Blow between them. Encourage students to try blowing gently at first, and then with more force.
3. Instruct students to observe what happens to the papers.

E. Wrap-up

1. Ask students to explain what happened.
   Instead of flying apart, the papers come together. The air moving rapidly between the two pieces of paper has less pressure than the air pressing on the outer sides of the paper.

2. Have students compare results. Was the resulting lift better when the students blew gently or when they blew with more force?

F. Activity III – Lift and Air Pressure

1. Have the students hold a hair dryer vertically so the stream of air goes straight up.
2. Release a ping-pong ball into the stream of air about a foot from the hair dryer. (Using a cool setting will work without the chance of overheating the dryer.) The ping-pong ball should stay suspended in the air stream.
3. Have students slowly tip the hair dryer so that the air shoots at an angle. The ball should stay suspended until the force of gravity makes it drop.

G. Wrap-up

Ask students to explain what happened.

The fast moving air stream causes low air pressure especially on top of the ball. This area of lowest pressure causes lift. This demonstration shows Bernoulli's Principle at work.

Activity IV – Differences in Air Pressure

1. Show the students the bags.
2. Give each cooperative group one bag. Have them tie one end of the bag close to the end.
3. Students will then brainstorm the various ways the bag could be inflated without actually doing so. See attached worksheet.
4. Share these ideas with the entire class and have each group pick one way to inflate the bag.
5. They will do this method as a demonstration to the rest of the class.
6. Allow the students to discuss the particulars of their demonstration and give them a few minutes to practice.
7. At least one group will choose the method of blowing the bag up like a balloon. Allow this group to demonstrate that method last. Before they do so, have the class estimate how many breaths it will take to blow up the bag. Record those estimates on the board.
8. After each group has blown up their bags, record their method of inflation, the amount of time it took to inflate the bag and the length of the inflated part of the bag on a chart on the board.
9. Discuss the various ways they inflated the bags. Compare the methods in terms of length of inflated bag and the amount of time it took to blow up the bag. Which method was most efficient in terms of the amount of air in the bag and which was most efficient in terms of the time it took to inflate the bag?
10. After this discussion, tell the students you can blow up the bag with only one breath.
11. Ask for comments.
12. Demonstrate. Have a student help you by holding one end of the bag and you hold the other so the bag is stretched out. Blow into the bag with a large puff of air. Have the students time you and also measure the length of the inflated part of the bag.

Lift-Off!
Activity

1. In your groups, brainstorm ways to inflate the airbag. Record them.

2. Choose a method your group will use to inflate the airbag. Practice your method and prepare to demonstrate it to your class. After your demonstration is complete, record the results of your experiment on the graph below. As the other groups demonstrate their methods, record those results also.

3. Which method showed the fastest way to inflate the airbag?

4. Which method inflated the airbag to the longest length?

5. Which method was the most efficient way of inflating the airbags? Support your answer.

H. Activity V: Applying Bernoulli's Principle to Flight

Step 1: Flat Wing

1. Cut a strip of paper 8 x 2 1/2 inches.
2. Fold the strip in half lengthwise. Tape the unfolded edge. Crease the folded edge.
3. Use a hole punch and make a hole one-inch from the folded edge. Make sure to punch through both sheets and that the hole is centered.
4. Cut a drinking straw to the length of 4 inches. Push the straw through the hole. Secure the straw with a little glue.

Step 2

1. Place the end of a 2 ft. 1/8" dowel rod in a ball of clay about 2" in diameter. The clay is used to support the dowel rod.
2. Cut a drinking straw to a 3" length. Slide the straw on the dowel rod and let it fall to the bottom.

Step 3

1. Slide the flat wing structure over the dowel rod.
2. Use a hair dryer to blow over and under the structure.
3. Observe results. Has your flat wing lifted? Ask students to explain what happened.

Step 4: Airfoil Wing

1. Cut a strip of paper 8" x 2 1/2".
2. Label one side of the strip **A**. Using a ruler, measure a 1/2" from the side of the strip and draw a line.
3. Turn strip over and label the opposite side **B**.
4. Carefully pull edge **B** over to the **A line** to bend paper. Do Not Fold. This will create a bowed figure similar to an airplane wing.
5. Tape the edges together.
6. Use a hole punch and make a hole 1" from the bowed or curved edge. Make sure to punch through both sheets and that the hole is centered.
7. Cut a drinking straw to the length of 4". Push the straw through the holes. Secure the straw with a little glue.

Step 5

1. Slide the airfoil wing structure over the dowel rod.
2. Use a hair dryer to blow over and under the structure.
3. Observe results. Has your airfoil wing lifted?

J. Wrap-up

1. Ask students to explain what happened. The flat wing did not create lift. Why?
2. In groups, have students make a drawing of a cross-section of both the flat wing and the airfoil wing. Prompt them to draw in the airstreams around the wings. Show how the airfoil wing is designed to accommodate Bernoulli's principle.

Assessment

Students should be evaluated on their ability to understand and explain each activity, and on the accuracy of their drawings.

Extensions

1. Have the students write to a local airline and acquire information dealing with the flight of an airplane.
2. Ask students to investigate how Bernoulli's principle applies to a bird's wing?

Resources/References

Devonshire, Hilary. *Flight*. New York: Franklin Watts Inc., 1992.
Dixon, Malcolm. *Flight.* New York: The Bookwright Press, 1991
Hixson, B.K. *Bernoulli's Book*. Salt Lake City: The Wild Goose Company, 1991.
Maurer, Richard. *Airborne.* New York: Simon & Schuster Inc., 1990
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Making Airfoils To Investigate Air Pressure

Flat Wing

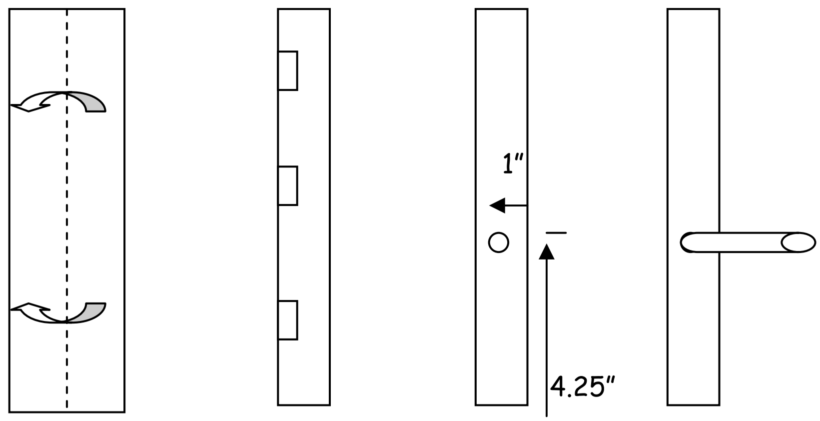


Fig.1 Fig. 2 Fig. 3 Fig. 4

1. Fold a 8.5”x2.5” strip of paper in half lengthwise.
2. Tape the unfolded edge to hold it together.
3. Use a hole punch to make a hole in the center of the length and 1” from the folded edge.
4. Push a 4” piece of a straw through the hole.

Airfoil Wing

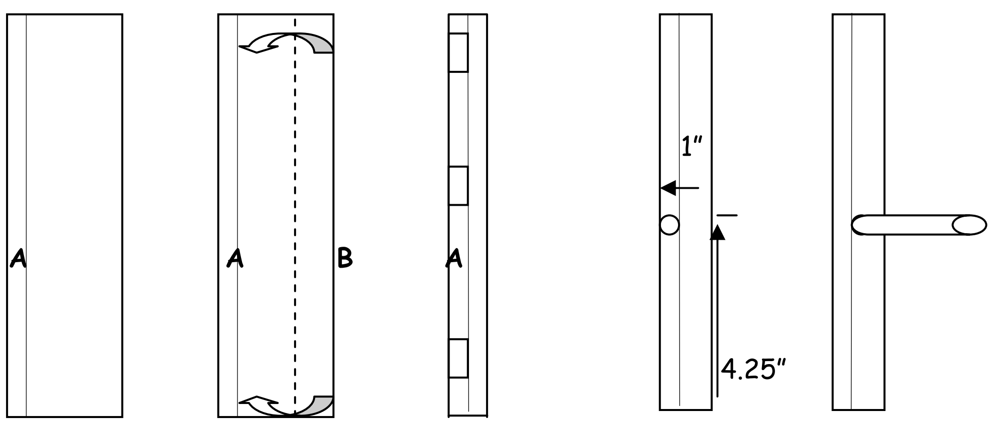


Fig.1 Fig. 2 Fig. 3 Fig. 4 Fig. 5

1. Measure .5” from edge **A**. and draw a line the length of the strip of paper.
2. Fold the paper lengthwise so the edge **B** touches **line A**. Do not push down on the folded side. It should form an arc.
3. Tape the unfolded edge at **line A** to hold it together.
4. Use a hole punch to make a hole in the center of the length and 1” from the folded edge.
5. Push a 4” piece of a straw through the hole.

Similar Paper Airplanes

Grade Level: 5 **Subject Area:** Science & Math

Time Required
Preparation: 1 hour
Activity: 1 hour

National Standards Correlation
Science (grades 5-8)
- Science and Technology Standard: Understanding about science and technology Standard.
- Physical Science Standard: Motions and forces.

Math (grades 3- 5)
- Geometry Standard: Analyze characteristics and properties of two- and three- dimensional geometric shapes and develop mathematical arguments about geometric relationships.
- Measurement Standard: Apply appropriate techniques, tools, and formulas to determine measurements.- Choose an appropriate unit and measure lengths and widths to a specified degree of precision in customary measurement

Summary
Students will construct a paper airplane and a similar one half scale in size. The distance each airplane will fly will be compared.

Objectives
Students will:
- Build a paper airplane following written and verbal instructions.
- Build a similar airplane, half-scale in size.
- Reach a conclusion about how size affects the distance flown.

Background
See Principles of Flight Introduction and the “Paper Dart Airplane” lesson.

Materials
- paper airplane pattern
- paper (8 ½” x 11”)
- scissors
- ruler
- colored pencils
- pencil

Safety Instructions: Do not fly paper airplanes directly at another person. Use caution when flying the paper airplanes. Create a single direction flight zone. Be sure that students stop flying their airplanes when other students are retrieving airplanes that have already landed.

Procedure

Warm Up

1. Discuss symmetry. Explain that it is important to keep the wings symmetrical.
2. Discuss similarity. Explain that it is important to measure carefully.
3. Review the four forces of flight (lift, drag, thrust, gravity).

Activity 1:

1. Using the paper airplane pattern as a guide, students will measure the dimensions, divide in half and cut out the resulting rectangle.
2. Using the paper airplane pattern as a guide, students will measure, double, and determine placement of all fold lines and cut lines. When complete they should have a similar paper airplane pattern, half-scale in size.
3. Decorate with colored pencils if desired.

Activity 2:

1. Students will construct each paper airplane. (See the "Paper Dart Airplane" lesson).

Activity 3:

1. Students will fly each plane, recording which flies the longer distance a total of 5 times.

Wrap Up

1. Students will compare their results with their classmates. Discuss the results.

Assessment/Evaluation

Student's airplanes will be checked for similarity. Students can be evaluated by teacher observation of student's participation in the activity.

Extensions

1. Using the original paper airplane pattern, students could make a double size airplane and conduct the same experiment.

Controlling Flight: Rudders, Ailerons, And Elevators

Grade Level: 5 **Subject Area:** Science

Time Required
Preparation: 1 hour
Activity: 1 hour

National Standards Correlation
Science (grades 5-8)
- Science as Inquiry Standard: Abilities necessary o do scientific inquiry.
- History and Nature of Science Standard: Nature of science.
- Unifying Concepts and Processes Standard: Evidence, model and explanation.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.

Summary
Students will construct paper gliders and conduct a series of test flights to discover how the rudder, elevators and ailerons affect flight. Students will measure distances flown and use a stopwatch to determine time aloft for each glider flight.

Objectives
Students will:
- Construct a glider
- Predict and observe how the rudder, aileron and elevator affect flight
- Measure distance flown
- Use a stopwatch to determine time aloft

Background
The rudder on the vertical fin steers the plane right or left. This is referred to as yaw. An elevator points the nose of the plane up or down. This is the pitch of the plane. Ailerons help to keep the plane steady and assist in tilting it while making a turn so that the wing on one side is lower than the wing on the other side. This is referred to as roll.

Materials
Each student will need:
- glider pattern
- heavyweight paper
- straw
- tape
- scissors
- paper clip

For the class you will need:
- stopwatch

- tape measure (either standard or metric)

Safety Instructions: *Do not fly paper gliders directly at another person because the pointed tip could cause injury. Use caution when flying the paper airplanes. Create a single direction flight zone. Be sure that students stop flying their airplanes when other students are retrieving airplanes that have already landed.*

Procedure

A. Warm-up

1. Explain to the class the function of the rudder, ailerons and elevators.

B. Activity

1. Cut out the three shapes from the pattern. Cut the slits in the wings and fin, but **do not fold them back**.
2. Fold the wing in half along the center dotted line. Fold each wing back along the second dotted lines. Tape the straw on top of the wing so that it sits on top of the folds. The folded section underneath the straw will assist in launching the glider.
3. Tape the tail to the end of the straw so that the end of the straw is lined up with the center of the tail.
4. Cut a slit at the top of the straw at the tail end. Insert the fin vertically into the slit and tape it into place.
5. Attach a paper clip to the nose.
6. Test the glider in a large, indoor area (such as a gymnasium). At one end of the gym, put a piece of masking tape on the floor to designate where the student will stand to launch the glider. For the first flight, leave the rudder, ailerons and elevator flat.
7. Measure and record how far the glider flew, the distance it flew, how straight it flew, and the length of time the glider was aloft. Record results on the Recording Sheet.
8. Now it is time to discover how the rudder, ailerons and elevator can affect the flight of the glider. First, students will predict what affect each change will have on the glider. Then, changing only one variable at a time, students will test fly the glider and record results.
9. Record results.

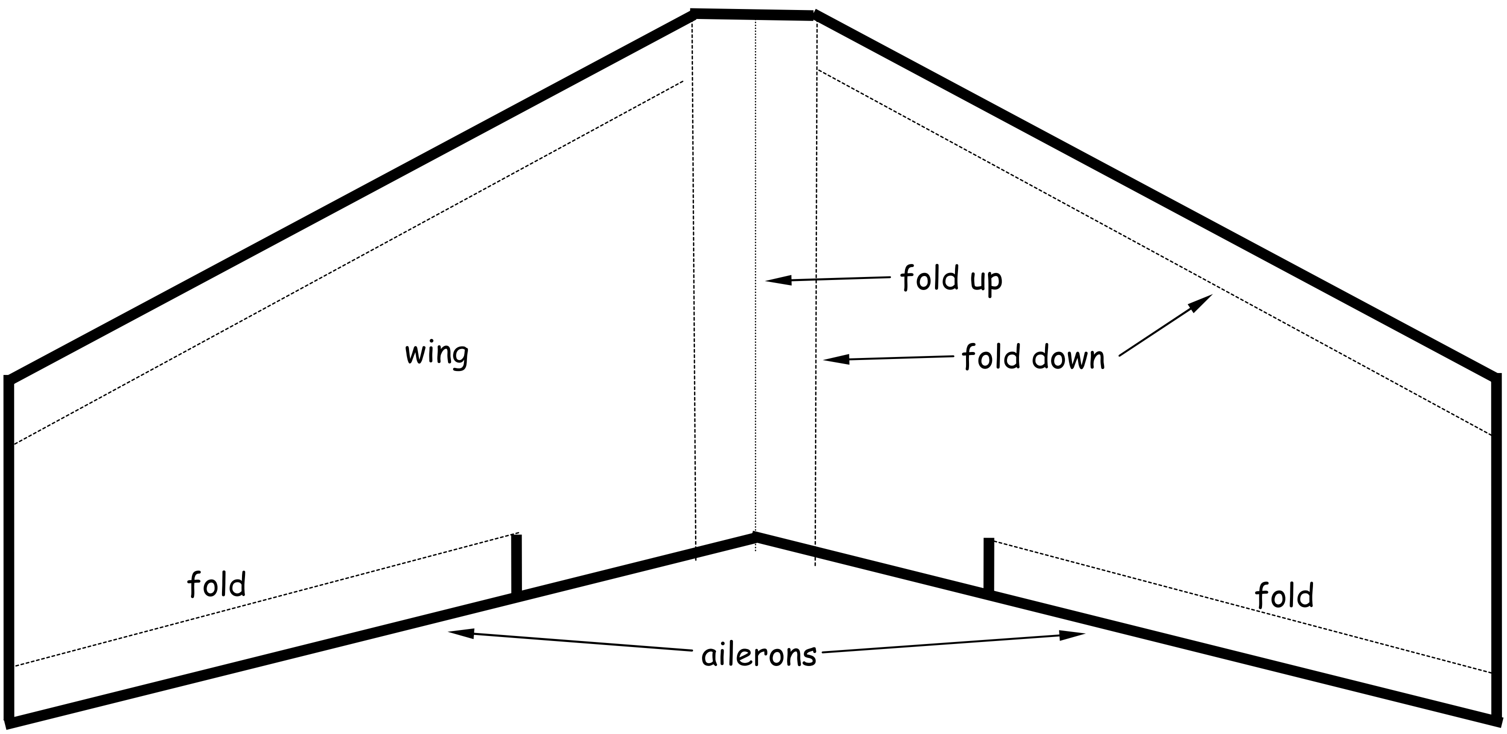
Assessment/Evaluation

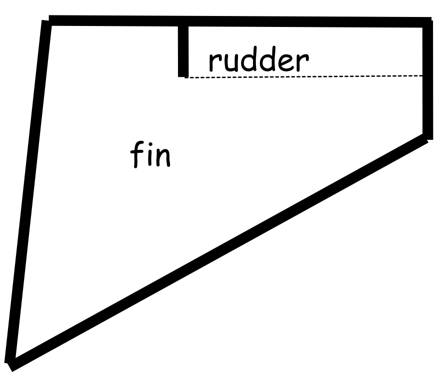
Students will write a paragraph explaining observations made during the various test flights.

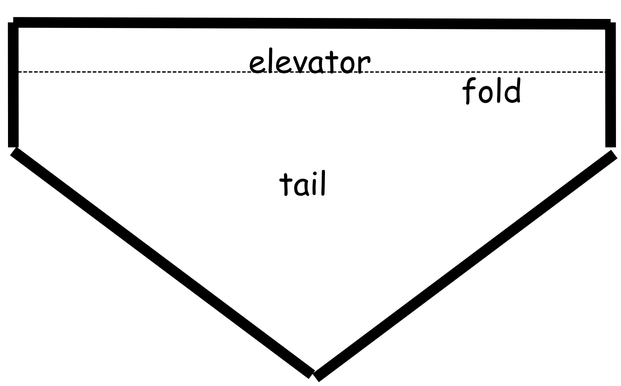
Extensions

1. Create a graph comparing the results of the glider's time aloft when the elevators are flat as opposed to bent. Calculate a class average.
2. Write a creative story about a flight where the rudder, ailerons and elevators were frozen. What would happen?
3. Have a contest to determine which glider stays aloft the longest, flies the farthest or is the most accurate.
4. Put a master copy of the glider on the overhead projector and have students measure and draw their own pieces to be cut out.

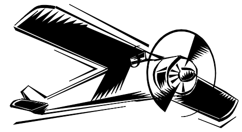
Controlling Flight: Rudders, Ailerons, And Elevators







	Time Aloft	Distance Flown	Direction Of Flight: Straight, Right, Left	Observations
Rudder Folded Left				
Rudder Folded Right				
Elevator Folded Up				
Elevator Folded Down				
Ailerons Folded Up				
Ailerons Folded Down				
One Aileron Folded Up, One Folded Down				



How Did Bessie Do That? Controlling Flight II

Grade Level: 5-6 **Subject Area:** Science

Time Required
Preparation: 30 minutes
Activity: Three 45 minute sessions

National Standards Correlation
Science (grades 5-8)
- Unifying Concepts and Processes Standard: Evidence, models and explanations.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.

Summary
Students will be read the picture book Nobody Owns the Sky, by Reeve Lindbergh and perform the play, "Freedom to Fly" by Renee C. Rebman. Students will construct paper gliders and conduct test flights to observe how the rudder, ailerons, and elevator affect flight patterns. Students will record results as each variable is tested. Students will identify control surfaces of real airplanes and understand their relationship to basic airplane maneuvers.

Objectives
Students will:
- Build and fly a glider
- Predict and observe how the rudder, ailerons and elevator affect flight.
- Measure distance flown
- Record flight patterns
- Make necessary adjustments to the ailerons, elevator, and rudder to control flight patterns.
- Read and perform the play, "Freedom to Fly" by Renee C. Rebman.
- Discuss the treatment and success of Bessie Coleman in relationship to social standards at the turn of the century.
- Identify maneuvers of yaw, pitch, and roll.

Background
The rudder on the vertical fin steers the plane right or left. This is referred to as yaw. An elevator points the nose of the plane up or down. This is the pitch of the plane. Ailerons help to keep the plane steady and assist in tilting it while making a turn so that the wing on one side is lower than the wing on the other side. This is referred to as roll.

Materials
Each student will need:
- glider pattern
- heavyweight paper or tagboard
- straw
- tape
- scissors

- paper clip

For the class you will need:

- tape measure
- picture book, Nobody Owns the Sky
- several copies of "Freedom to Fly"
- stopwatch

Safety Instructions: Do not fly paper gliders directly at another person because the pointed tip could cause injury. Use caution when flying the paper airplanes. Create a single direction flight zone. Be sure that students stop flying their airplanes when other students are retrieving airplanes that have already landed.

Procedure

Day One

A. Warm-up

1. Read aloud Nobody Owns the Sky.
2. Discuss the treatment and success of Bessie in relationship to America's timetable.
3. Show poster of an airplane and have students predict the purpose of the rudder, ailerons, and elevators.

B. Activity

1. Cut out the three shapes from the pattern. Cut the slits in the wings and fin, but **do not fold them back.**
2. Fold the wing in half along the center dotted line. Fold each wing back along the second dotted lines. Tape the straw on top of the wing so that it sits on top of the folds. The folded section underneath the straw will assist in launching the glider.
3. Tape the tail to the end of the straw so that the end of the straw is lined up with the center of the tail.
4. Cut a slit at the top of the straw at the tail end. Insert the fin vertically into the slit and tape it into place.
5. Attach a paper clip to the nose.
6. Test the glider in a large, indoor area (such as a gymnasium). At one end of the gym, put a piece of masking tape on the floor to designate where the student will stand to launch the glider. For the first flight, leave the rudder, elevators, and ailerons flat.
7. Measure and record how far the glider flew, the length of time it was aloft, and how it flew (straight, turned right or left, up or down, etc.)

Day Two

1. Now it is time to discover how the rudder, ailerons and elevator can affect the flight of the glider. First, students will predict what affect each change will have on the glider. Then, changing only one variable at a time, students will test fly the glider and record their results.
2. Have a class discussion on their findings. For example, the rudder makes it turn right or left.
3. Now, the teacher will explain yaw, pitch and roll using a glider to model.
4. The teacher will call out maneuvers and the students will act out yaw, pitch, and roll while holding onto their planes.
5. The students will then try to perform specific maneuvers by making adjustments to their plane.

Day Three
1. Read and act out the play of Bessie Coleman Reader's Theater style.

Assessment/Evaluation
Students will be evaluated on their data sheets, ability to identify control surfaces and the maneuvers of an airplane. Students will write a paragraph explaining Bessie Coleman's role in the history of flight and describe why she is an African-American female pioneer in aviation.

Extensions
1. Watch video clip of Patty Wagstaff from *The Magic of Flight*.
2. Make a set, collect and design costumes, and perform the complete play, "Freedom to Fly" for parents and younger students.
3. Have an air show with categories for time aloft, distance, speed, stunts, and accuracy.
4. Read a biography about early aviators.

Resources/References
Lindbergh, Reeve. *Nobody Owns the Sky.* Cambridge, Massachusetts: Candlewick Press, 1998.

Where are We? – Understanding Aeronautical Charts and Topographic Maps

Grade Level: 7-8 **Subject Area:** Science and Math

Time Required
Preparation: 10 minutes
Activity: 4 hours

National Standards Correlation

Science (grades 5-8)
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.
- Science as Inquiry Standard: Understandings about scientific inquiry.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Science and Technology Standard: Abilities of technological design.

Math (grades 6-8)
- Measurement Standard: Apply appropriate techniques, tools, and formulas to determine measurements.
- Data Analysis and Probability Standard: Develop and evaluate inferences that are based on data.

Summary
"Topographic Field Trip" provides students with the opportunity to examine spatial information and relate it to real-world features through the use of sounds, graphics, text, animation, and interactivity in a game-like adventure. Students tour the nation's capital, examine historical maps, and refine their problem-solving skills. Upon completion of the field trip, students apply the knowledge they have gained by reading aeronautical charts from their local airport.

Objectives
Students will:
1. Analyze and interpret topographic maps
2. Examine historical maps
3. Measure distance and direction
4. Determine latitude and longitude
5. Learn map features
6. Reinforce knowledge of previously introduced terms
7. Retrieve information with a computer
8. Look at digital aerial photography

Background
Topography is the detailed mapping of the surface of the earth. Pilots use various sectional maps and aeronautical charts to fly their aircraft. Although these maps tend to change frequently because of land development, most of the symbols remain the same. Students can begin to understand and appreciate how pilots fly their aircraft by learning to recognize and understand some of the symbols on these maps. Sectional maps/aeronautical charts are available at most airports. These charts change approximately every 6 months. Ask for the older version of the maps-many airports will give these away for free.

Materials

U.S. Geological Survey CD-ROM entitled, "A Topographic Field Trip of Washington DC"
Available for Macintosh only-free of charge or dual platform, Macintosh/Windows
Write to:

US Geological Survey
Information Services
Box 25286
Denver, Colorado 80225-0286

Or visit: www.usgs.gov/

- sample aeronautical charts/sectional maps (available at airports), laminated
- dry erase markers (one per student)
- math and science journal

Procedure

A. Warm-up

- Discuss ways in which people can locate places. Ask, "How do pilots know where to fly?" (Note: Pilots use numerous instruments to control and fly airplanes, but what happens when the instruments fail? Pilots use special maps to locate features on the earth's surface.)
- Review airplane controls and the three dimensions in which aircraft fly (pitch, yaw, and roll).
- Review how to retrieve information from a computer.

B. Activity I

- Students complete computer-simulated topographic field trip individually or in pairs. (This will take up to four 45 minute class periods. The game contains its own instructions on what steps to take to complete the field trip, and students will learn how to read maps as the game progresses. Encourage students to make a journal of terminology and symbols used in reading these topographic maps.
- Give each student or team a sectional map upon completion of the field trip..
- Locate 3 different natural formations, and the highest and lowest natural elevations on their charts. Use the marker to circle and label each.

C. Wrap-up

- Students switch maps with other classmates, and determine if the answers are correct.

Assessment/Evaluation

Students should be evaluated on their ability to efficiently locate formations on topographic maps, and accuracy of journal entries.

Extensions

Create topographic maps of your own community.
Invite an aerial photographer or a cartographer to discuss his/her work with the class.

Resources

Aviation Fundamentals. Englewood, Colorado: Jeppesen Sanderson, Inc., 1986.
U.S. Geological Survey CD-ROM, "A Topographic Field Trip of Washington, D.C." 1997.

Propellers, Forces, and Energy

Grade Level: 7-8 **Subject Area:** Science

Time Required

Preparation: 1 - 50 min period
Activity: 2 - 50 min periods

National Standards Correlation

Science (grades 5-8)

- Unifying Concepts and Processes Standard: Evidence, models, and explanation.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Physical Science Standard: Motions and forces.
- Science and Technology Standard: Abilities of technological designs.

Math (grades 6-8)

- Measurement Standard: Apply appropriate techniques, tools, and formulas to determine measurements.
- Data Analysis and Probability Standard: Develop and evaluate inferences and predictions that are based on data.

Summary

Students will work in cooperative groups to build model airplanes of balsa wood, and observe the results when the number of propeller rotations is altered. The distance traveled by the model and the total duration (time) of flight will be used to calculate the average velocity and distance. Students will graph the average distance traveled versus the number of propeller rotations, interpret the data to discover relationships between the amount of potential energy (in the propeller) and the amount of work done (length of flight), and identify the types of energy and forces that relate to airplane flight.

Objectives

Students will:

1. Construct a model airplane out of balsa wood.
2. Measure distances and time of flight.
3. Calculate the average velocity for each trial.
4. Calculate the average distance for each trial
5. Graph the average distance traveled versus the number of turns of the propeller.
6. Interpret data to makes inferences about the relation between energy and work.

Background

Airplane engines push fast moving air out behind the plane (by either propeller or jet) causing the plane to move forward. The propeller provides the thrust to move the plane horizontally. In the model, potential energy is stored in the twisted rubber band powering the propeller. When the rubber band untwists, kinetic energy is released and work is done in turning the propeller. The propeller provides the thrust, which pushes the airplane forward according to Newton's Third Law. As the plane moves forward through the air, lift generated by the shape of the wings allows the airplane to fly. The lift force acting on an airplane is weakest at take-off and landing since the lift has a smaller value at lesser speeds. Changing the shape of the wing using ailerons and flaps increases the surface area of the wing, which adds extra lift at slow speeds. (See Principles of Flight Introduction.)

Materials (per group)

balsa wood model airplane with propeller (such as Delta Dart - Midwest Products Co)
scissors
glue
rubber band
pin
meter stick or measuring tape
stop watch
post-it notes (2 in by 1 in)
flight data log
graph paper

Safety Instructions: Do not fly model planes directly at another person. Use caution when flying the models. Create a single direction flight zone. Have all students stand behind the "takeoff" line. Give an "all clear" signal when it is time to fly the planes, and do not allow students to cross the "takeoff" line to retrieve airplanes that have already landed until a "retrieve all planes" signal has been given.

Procedure

A. Warm up

- Review the four forces acting on an airplane- lift, gravity, thrust and drag.
- Review Bernoulli's Principle and lift.
- Review potential and kinetic energy.
- Review Newton's Third Law.
- Introduce thrust and the function of the propeller.
- Review the jobs to be performed by each person in the group – pilot, recorder, observer, timer, and measurer.

B. Activity I

Build the model airplane, following the directions given with the model.

C. Activity II

Students will run one initial test flight of their airplane to make sure that the flight path is straight, and that the plane does not bank or turn excessively to the right or left.
1. Rotate the propeller clockwise 50 turns, and hold it there.
2. Hold the plane level.
3. When the "all clear" signal is given, students will release their planes. The observers will watch to see if the plane flies straight, the timer will record the time of the flight with a stopwatch.
4. When the "retrieve all planes" signal has been given, the measurer will use the measuring tape to measure the horizontal distance from the point of release to the point of landing. The recorder will record the data.

5. If any modifications are needed to make the planes fly in a fairly straight flight path, they should be made now with teacher input and another trial flight should bed done. Only correct severe flight problems. Use post-it notes to make modifications to ailerons and elevators.

D. Activity III

1. Rotate the propeller clockwise 25 turns, and hold it there.
2. Hold the plane level.
3. When the "all clear" signal is given, students will release their planes. The observers will watch to see if the plane flies straight, the timer will record the time of the flight with a stopwatch.
4. When the "retrieve all planes" signal has been given, the measurer will use the measuring tape to measure the horizontal distance from the point of release to the point of landing. The recorder will record the data.
5. Repeat the procedure two times for a total of three trials at this propeller rotation.
6. Repeat the trial flights with the propeller rotated clockwise 50 times, 75 times, 100 times and 150 times. Record all data in the flight data log.

E. Wrap up

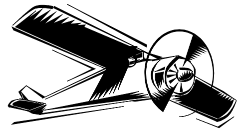
1. Students will calculate the average distance traveled and the average time of flight for the three identical trials.
2. Students will calculate the average velocity by dividing the average distance by the average time..
3. Students will create a graph of the number of turns of the propeller versus the average distance traveled.
4. Students will write a lab report, including objective, observations, data, and calculations and answer questions given on the Flight Data Log.

Assessment/Evaluation

Students will be evaluated on their lab report, the accuracy of their data and calculations, and the accuracy of their graph.

Extensions

1. Use EXCEL to set up the data table, calculations table and graph.
2. Calculate the kinetic energy for each trial.
3. Find the stored potential energy of the propeller from the velocity of the propeller and compare with the kinetic energy of the plane. Discuss the drag force, which prevents the two energies from being equal.



Propellers, Forces, and Energy

Flight Log Name ________________

Initial Flight Data

Number of Propeller Rotations	Description of Flight	Distance	Time	Modifications Needed
50				

Flight Trials

Number of Propeller Rotations	**Distance**	**Time**	**Average Distance**	**Average Time**

Questions:

1. Is the relationship between the number of propeller rotations and the distance traveled linear? If not, why not?
2. What provides the kinetic energy for the plane?
3. What purpose does the propeller serve?
4. What provides the thrust for the plane?

Balsa Wood Airplane Flight and Speed Correlation

Grade level: 9 **Subject:** Physical Science

Time Required
Preparation: 50 minutes
Activity: 3-4 class periods

National Standards Correlation
Science (grades 9-12)
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Physical Science Standard: Motions and forces.

Math (grades 9-12)
- Algebra Standard: Use mathematical models to represent and understand quantitative relationships.
- Number and Operations Standard: Compute fluently and make reasonable estimates.
- Measurement Standard: Apply appropriate techniques, tolls, and formulas to determine measurements.
- Data Analysis and Probability Standard: Develop and evaluate inferences and predictions that are based on data.

Summary
The purpose of this lesson is to test the flight of model airplanes built by the students. This is a cumulative activity to summarize the facts and applications learned about flight. Students will construct a balsa wood airplane and correctly identify the main parts of the plane and the purposes of each. They will then test fly their models and make adjustments by adding elevators, ailerons, and rudders for a straight flight path. Finally, students will record time and distance data for their plane, and use it to calculate the speed of the airplane.

Objectives
- Apply the scientific method to solve a problem.
- Relate flight path with the parts of an airplane.
- Display data through graphs.
- Interpret data as individuals and as a class.
- Learn the relationship of time to distance and speed.
- Relate flight to Newton's Third Law (action-reaction pairs).
- Relate flight to Bernoulli's principle (air pressure).

Background
The rudder on the vertical fin steers the plane right or left. This is referred to as yaw. An elevator points the nose of the plane up or down. This is the pitch of the plane. Ailerons help to keep the plane steady and assist in banking when making a turn. This is called roll.

Materials (per student)
- balsa wood propeller airplane kits

- cardboard squares (18" x18")
- cutting knives
- wood glue
- clear tape
- mini sticky notes
- tape measure
- stopwatch (per group)
- (2) ground stakes (to mark runway distance)

Safety precautions:
Please remind students of the cautions needed when working with knives. Do not fly model planes directly at another person. Use caution when flying the models. Create a single direction flight zone. Have all students stand behind the "takeoff" line. Give an "all clear" signal when it is time to fly the planes, and do not allow students to cross the "takeoff" line to retrieve airplanes that have already landed until a "retrieve all planes" signal has been given.

Procedure:

1. Warm-up

Explain the activity to the students.
- Review the four forces of flight (lift, drag, thrust, and gravity).
- Review Bernoulli's Principle using the wing of an airplane.
- Review the functions of the ailerons, elevators, and tail.
- Review the terms Pitch, Roll, and Yaw.
- Review the distance formula. (distance = rate x time)

B. Activity I

Each student should receive a building kit, cardboard, and a cutting knife.
- Tape the pattern to the cardboard, and write names on all materials.
- Follow the instructions for cutting out and assembling the airplane.
- Store airplanes in a very safe, undisturbed area overnight to allow the glue to dry.

C. Activity III

The students will do their test flights either inside (gymnasium) or out on a field. Stress to students that observations of the flight path must be accurate in order to make the proper modifications necessary to make it fly straight.

1. Rotate the propeller clockwise 50 turns, and hold it there.
2. Hold the plane level.
3. When the "all clear" signal is given, students will release their planes. The Observers will watch to see if the plane flies straight.
4. Record observations of the flight path of the plane in the flight log.
5. Repeat the trial flight with the propeller rotated clockwise 75 times and 100 times. Record observations about the plane's flight in the flight log for each test flight.

D. Activity III

- Look at the observations in the flight log. Did the plane fly straight? Curve left or right? Dive down or up?

- Determine which type of control modification will be needed to correct the flight problem.
- Use stick-back notes to add the controls necessary (elevators, ailerons, and rudders) in order to correct the control problem.
- From the same pre-determined spot, allow each student 3 test flights to get a straight flight pattern.
- Students should indicate on their data page, with a sketch, what modifications they made to their airplane.

E. **Activity IV**

- Have a pre-measured runway of 10 meters for the students to line up behind.
- Students should work in pairs for this portion of the unit.
- One student will be the Timer and the other will fly the plane.
- Wind the airplane 100 times.
- On a count of 3, simultaneously throw the plane and start the watch. When the plane passes the 10-meter marker stop time.
- Record the time in the data table.
- Repeat the experiment for a total of three test flights.
- Calculate the average speed and the average distance for the three flights.
- Use the distance formula to calculate the speed (rate) of the plane.
- Graph the results and compare with the rest of the class.

F. **Wrap-up:**

- Discuss the significance of adding ailerons, elevators, and rudders.
- Explain the relationship between time, distance, and speed.
- Discuss how the adjustments to the airplanes relate to Bernoulli's principle.
- Compare speeds of the different airplanes and make a class data table of results.

Assessment/Evaluation:

Ask students to explain the function of time and distance when calculating speed. Students should be able to apply their experience and find the speed of other objects.

Extensions

Observe the flight of other objects.

Balsa Wood Airplane Flight and Speed Correlation

Name: ______________________

Flight Log

Observations:

In the space below, make a diagram of where you added tabs for ailerons, elevators, and rudders. Properly label each part.

Distance of Flight (m)	Time Aloft (seconds)

3. In the grid below, create a bar graph of your data.

X-axis: time (seconds) **y-axis: Distance** **Title: Airplane Speed**

4. Calculate the average speed of your airplane:

Average Distance (d): ___________ Average Time (t): _________

Speed = d / t _____________ / _______________ = ________________m/s

Fly, Kimoto Flyer, Fly!

Grade Level: 9-12 **Subject Area:** Science

Time Required
Preparation: 15 min
Activity: 1 - 50 min period

National Standards Correlation
Science (grades 9-12)
- Science as Inquiry Standard: Understanding about scientific inquiry.
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Unifying Concepts and Processes Standard: Change, constancy, measurement.
- Unifying Concepts and Processes Standard: Systems, orders, and organization.
- Unifying Concepts and Processes Standard: Evidence, models and explanation.
- Physical Science Standard: Motions and forces.
- History and Nature of Science Standard: Scientific knowledge.

Summary
Students will work in cooperative groups to build a Kimoto flyer following directions. The model will be used to discuss principles of flight and the forces acting on an airplane. Students will then use the Kimoto flyer to collect data on the force applied, the distance traveled and the time of flight.

Objectives
Students will:
1. Construct a Kimoto flyer following instructions.
2. Investigate the forces acting on the flyer.
3. Measure the thrust force with a spring balance.
4. Calculate the stored energy in the rubber band.

Background
See Principles of Flight Introduction

Materials (per group)
- Kimoto Flyer pattern (see pattern section)
- spring balance (0-10 N)
- styrofoam plate (10.5 in)
- 2 large paper clips
- scissors
- transparent tape
- rubber band (4 in)
- pliers (to bend paperclip)
- meterstick or measuring tape

- stopwatch
- electric balance

Safety Instructions: Do not fly model planes directly at another person. Use caution when flying the models. Create a single direction flight zone. Have all students stand behind the "takeoff" line. Give an "all clear" signal when it is time to fly the planes, and do not allow students to cross the "takeoff" line to retrieve airplanes that have already landed until a "retrieve all planes" signal has been given.

Procedure

A. Warm-up

- Review potential energy (U) and kinetic energy (K).
- Review balanced and unbalanced forces.
- Review the four forces of flight (lift, drag, thrust and gravity).
- Review Bernoulli's Principle using the wing of an airplane.
- Review the distance formula. (d=rt)
- Review the terms Pitch, Roll, and Yaw.
- Review the individual jobs in the group: Pilot, Timer, Measurer, Recorder

B. Activity I

Students will use the pattern to construct the Kimoto flyer.

- Cut out the circle of the pattern.
- Place the pattern on the bottom of an inverted styrofoam plate.
- Tape the pattern to the plate.
- Use a pen to score the solid and dashed lines through pattern and into the plate. Remove the pattern, cut out all solid lines, and use a ruler to score dashed lines. Make sure they are parallel.
- Bend the centerline (main body) down and pull tail up along dashed lines.
- Bend a large paper clip at a 90 degree angle in the first 0.5 cm. Use the open end of paperclip. This becomes a hold back fitting for launching the flyer.
- Place the closed ends of paper clip (not bent) on the front of the airfoil so that it will fit above and below the leading edge. Tape it to the top and bottom to hold in-place and to retain slight 'V' shape of flyer.
- Make rubber band catapult from large paper clip for launching purposes.
- Launch 'flyer' by attaching loose end of catapult rubber band to hold back fitting on nose of the flyer. Apply tension between catapult and flyer, holding the body of the flyer (not tail) and release the flyer away from any object that it might strike.

C. Activity II

- Do several practice launches.
- Measure the length of the rubber band at rest (not stretched) in mm, and record the data in your Flight Log
- Attach the spring balance to the rubber band, and use it to launch the flyer and measure the force.
- Pull back in a "launch ready" position with a 2.0 N force. Measure the length of the stretched rubber band in mm, and record the length and the force in the Flight Log.

- Launch the flyer with the 2.0 N force. Use a stopwatch to measure the time of flight.
- Measure the horizontal straight line path taken by the flyer in meters. Record data.
- Repeat steps 2 - 6 for a total of 3 trials.
- Repeat experiment with a 4.0 N force, a 6.0 N force and a 8.0 N force. Do three flights for each force. Record all data.
- Mass the flyer.

D. Activity III

- Calculate the average distance traveled and average time of flight for each force.
- Calculate the average velocity for each force.
  Average velocity = (average distance) /(average time of flight).
- Calculate the kinetic energy of the flyer.
  $K = 1/2 \ mv^2$
  where m is the mass of the flyer and v is the velocity of the flyer.

2. Calculate the average force for 2.o N, 4.0 N, 6.0 N, and 8.0 N. (A better value for the force could be found. See extension.)
3. Calculate the stored energy (i.e - potential energy (U)) in the rubber band
   U = (average force)(stretch of the rubber band in meters).
4. Calculate the difference between the stored energy of the rubber band and the kinetic energy of the flyer.
   K - U

E. Wrap-up

- Compare and contrast the length of the stretched rubber band with the velocity and distance traveled. What hypotheses can the class infer about the relationships of these three pieces of information?
- Compare and contrast the amount of stored energy in the rubber band (U) with the force N and the velocity and distance traveled. What hypotheses can the class infer about the relationships of these three pieces of information?
- Discuss the amount of variability in measurements in the 3 trials using the same force. What factors could have contributed to the variability of data? What was the importance of finding the average distance, time, velocity, and force?
- Compare and contrast the average information from all the groups. Does this larger data sample increase the accuracy of the measurements?
- Compare and contrast the difference in Potential and Kinetic energy produced from the rubber bands in all of the teams' experiments. What relationship exists between the potential energy and the kinetic energy? What conclusions can the class infer about the quality control of rubber bands production?

Assessment/Evaluation

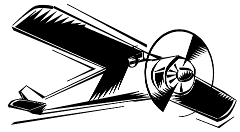
Students will be evaluated on accuracy of measurements and calculations, and participation in class discussions.

Extensions

1. Use a spreadsheet program to construct data and calculations tables.

2. Find a better value for the force applied by using calculus and integration. The force on the length of the rubber band is not a linear function. For higher grades, you could use Hooke's Law to find the value of k in $F_{(x)} = -kx$. for the rubber band. The value for k will not be a constant; it will be a function of x where $F_{(x)}$ is the spring force, x is the amount of stretch, and k is the stiffness of the rubber band. Then integrate F =dx to find the work done which is the stored potential energy of the rubber band.

5. Use different rubber bands to show the stored energy is different for different elastic bands.



Fly, Kimoto Flyer, Fly!

Flight Log

Mass of Flyer_______________
Length of Rubber Band at Rest_______________

(f) Force (N)	Length of Rubber Band (mm)	(m)	(t) Time (sec)	(d) Distance (m)	$\vec{(v)}$ Velocity (m/sec)	Avg d (m)	Avg t (sec)	Avg v (m/sec)	Avg f (N)	PE	K - U
2.0 N											
4.0 N											
6.0 N											
8.0 N											

Gyrocopters – Producing Rotary Motion

Grade Level: 10-12 **Subject Area:** Physical Science/Physics

Time Required
Preparation: 30 minutes
Activity: (2) - 50 minute class periods

National Standards Correlation
Science (grades 9-12)
- Science as Inquiry Standard: Ability Necessary to do scientific inquiry.
- Unifying Concepts and Processes Standard: Evidence, models and explanation.
- Unifying Concepts and Processes Standard: Form and function.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Physical Science Standard: Motions and forces.

Summary
Students will work in cooperative groups of three and use self-made gyrocopters to examine the production of rotary motion. Students will be instructed to experiment with different gyrocopter construction materials, blade orientations, blade lengths and mass distributions in order to determine how such variation effect torque (both clockwise and counterclockwise) and rotational inertia.

Objectives
Students will:
- Construct gyrocopters following verbal, visual, and written instructions.
- Demonstrate rotary motion using the gyrocopters.
- Investigate how changing variables of blade orientation, blade length, and mass distribution affect rotary motion.
- Make and record observations.
- Determine the relationship existing between torque arm length and torque, and between mass distribution and rotational inertia.
- Explain why blade orientation determines whether applied torque will be clockwise or counterclockwise.

Background
A gyrocopter is a simple device that, like a helicopter, operates using rotary motion. Helicopter rotors are, essentially, rotating wings. Rotary motion is defined as the spinning motion of a body about an internal axis. Newton's laws govern all forms of motion, including rotary. Newton's second law informs us that an object accelerates linearly (in as straight line) as a result of an applied force. If applied forces produce linear motion, what produces rotary motion? Torque is said to be to rotary motion what force is to linear motion. Commonly, torque is defined as the product of an applied force and the length of its torque arm, that is, the distance between the point of force application and the point of rotation or the spin axis. Therefore, any object that rotates or spins does so due to an applied torque. It is easy to observe that rotary motion can occur in either a

clockwise or counterclockwise direction. As a result, torque is also designated as clockwise or counterclockwise.

Newton's first law must also be considered when examining rotary motion. The first law implies that all objects possess inertia, which is defined as a resistance to a change in motion or position by an object. Inertia is directly related to mass, meaning that the more massive the object is the greater the inertia it possess. From this relationship, we know that objects with greater inertia require greater forces to be applied in order to change their states of motion or position linearly. When considering rotary motion, objects with the ability to spin possess rotational inertia. Rotational inertia not only depends upon the total mass of the object, but also the distribution of the mass within or upon the object. Therefore, the greater the rotational inertia, the more torque must be to produce to change the object's rotation.

Materials (per group)

- gyrocopter template/pattern (See patterns section at end of curriculum guide)
- pencil
- paper
- paperclips (for added weight)
- scissors
- metric rulers
- construction materials such as: construction paper, typing paper, poster board, paper bags, lightweight vinyl or plastic

Safety Instructions: Follow all pre-established lab safety guidelines and expectations.

Procedure

A. Warm-up

- Review Newton's three laws of motion.
- Discuss rotary motion in terms of torque and rotational inertia.
- Review the job of each member of the group: Pilot, Measurer, and Recorder.

B. Activity I

1. Choose a construction material from those provided.
2. Construct three gyrocopters from the same material using the master pattern sheet, but vary the blade length for each gyrocopter.

- Cut on the solid black lines.
- Fold on the dotted line at "A" so the fold does not cover the name.
- Fold on the dotted line at "B" so the fold does not cover the name.
- Fold on the dotted line at "C" so the fold does not cover the name.
- Fold on the dotted line at "D" so the fold does not cover the name, and fold on the dotted line at "E" so the fold covers the name.
- Bring the two "wings" up so they are perpendicular to the ABC section.

C. Activity II

- Fly each gyrocopter by releasing it from overhead.
- For each gyrocopter, observe the direction of spin.
- Record spin direction on the Flight Data Log.

- Switch blade orientation and observe and record resulting changes in the rotary motion of the gyrocopter.
- Repeat steps 1 – 4 for each gyrocopter.
- Measure and record the blade lengths of all three gyrocopters in centimeters.
- Compare and contrast the rotary motion of all three and record your observations.
- Using the first gyrocopter constructed, vary mass distribution along the blades and rotational axis by adding more paper clips. Conduct at lest three variations.
- Repeat this step with the other two gyrocopters.
- Compare and contrast the rotary motion when more weight is added, and record your observations.
- Label and save all gyrocopters constructed during this activity for use in an additional lab on rotary motion.

D. Wrap-up

- Analyze all recorded observations and collect data.
- Discuss and compare results with other lab groups.
- Write a conclusion based on the analysis of your results. Within your conclusion explain the relationship you observed to exist between blade length and torque, and mass distribution and torque.

Assessment/Evaluation

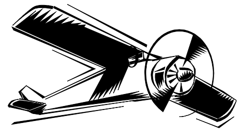
Students will be evaluated on the accuracy of observations, collection and organization of data, and conclusion responses.

Extension

Choose two different construction materials and construct two additional gyrocopters the same size as the first. Repeat the experiment. Record, compare, and contrast the rotary motion of these three different gyrocopters. These gyrocopters of different materials will be used in the next activity: "**Gyrocopters – Describing Rotary Motion".**

Resources/References

Hixson, B.K. "Tubular Copters." The Wild Goose Company, Salt Lake City, UT 84115, 1991.

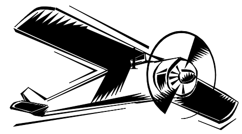


Gyrocopters – Producing Rotary Motion

Name ________________

Flight Data Log

Gyrocopter Number	Construction Material	Blade Length (cm)	Number of Paper Clips	Direction of Rotary Motion	Number of Rotations (Torque)
1					
2					
3					



Gyrocopters – Describing Rotary Motion

Grade Level: 11-12 **Subject Area:** Physics

Time Required
Preparation: 30 minutes
Activity: One class period (50 minutes)

National Standards Correlation
Science (grades 9-12)
- History and Nature of Science Standard: Nature of scientific knowledge.
- History and Nature of Science Standard: Science as a human endeavor.
- Unifying Concepts and Processes Standard: Evidence, models, explanation.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Unifying Concepts and Processes Standard: Systems, order, and organization.
- Science as Inquiry Standard: Understandings about scientific inquiry.
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Physical Science Standard: Motions and forces.
- Science and Technology Standard: Understandings about science and technology.

Summary
Students will work in cooperative teams of three, and use self-made gyrocopters from the previous lesson (Gyrocopters-Producing Rotary Motion) to examine rotary motion in terms of angular displacement, angular velocity, and angular acceleration. Teams will calculate the average angular velocities for each gyrocopter tested as it falls by collecting the appropriate data of angular displacement and time of rotation, and will express their calculated angular velocities in the following units:
Revolutions per second, revolutions per minute, and radians per second. Students will apply the "right-hand rule" of angular velocity to determine the direction of the axis of rotation since vector quantities such as velocity require both magnitude and direction, and will explore how changes in the release height affects the average angular velocity calculations.

Objectives
Students will:
- Conduct experiments and record measurements of angular displacement.
- Conduct experiments and record measurements of rotation time.
- Calculate angular velocity value by applying the equation for angular velocity.
- Perform unit conversions.
- Apply the "right-hand" rule of angular velocity.
- Determine if height variations affect angular velocities achieved.

Background
There are various types of motion such as linear, free-fall, projectile, circular, and rotary. Though each is distinctively different, all can be described in terms of displacement, velocity, and acceleration. When it comes to rotary motion, it is described in terms of angular displacement, angular velocity, and angular acceleration. Angular displacement is the angle about the axis of

rotation through which the object turns and can be expressed in the units of revolutions, degrees, or radians. Angular velocity is defined as the time rate change in angular displacement. Angular acceleration is the constant rate of change of angular velocity. Even though the equations for each type of motion are specific, the basic means of description remains the same.

Materials

- 3 gyrocopters made of different materials (see **"Gyrocopters – Producing Rotary Motion" - Extensions**)
- pencils
- paper
- metersticks or metric tape measure
- calculators
- stopwatches

Safety Instructions: Follow all pre-established lab safety guidelines and expectations.

Procedure

A. Warm-up

1. Review the equation for the calculation of angular velocity. $\overline{W} = {}^{\varnothing_1 - \varnothing_2}/_{t_1 - t_2} = \Delta\varnothing/\Delta t$
2. Review unit conversion factors between revolutions, degrees, and radians.
3. Obtain the three gyrocopters from the previous lesson made of different materials, but of the same size.
4. Review the job of each member of the team. Timer, Recorder/Observer, Launcher.

B. Activity I

1. Teams select their own release height for the gyrocopters, and record it in meters on the Flight Data Log. The same release height will be used for all flight trials.
2. The Launcher releases the gyrocopter from the selected height and counts the number of revolutions or spins the gyrocopter undergoes as it "falls" to the floor. This is the angular displacement.. The timer records the total time of the gyrocopter's descent from the moment it is released until it touches the floor. The Recorder/Observer notes the direction of spin.
3. Record all data in the Flight Data Log.
4. Test each gyrocopter three times at this height, and record all data.
5. Noting the direction of spin for each gyrocopter, apply the "right-hand" rule to determine the direction of the angular velocity
6. Calculate and record the magnitude of the average angular velocity for each of the three gyrocopters.
7. Perform unit conversions from revolutions per second to revolutions per minute and radians per second.
8. Vary the release height for the gyrocopters at least twice, repeating steps 2-7 with each variation. Be sure to record the height chosen.

C. Wrap-up

1. Analyze all recorded observations, collected data, and calculations..
2. Discuss and compare results with other lab groups.
3. Write a conclusion based on the analysis of your results. Within your conclusion compare and contrast calculated average angular accelerations for each gyrocopter. Formulate possible

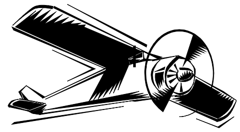
4. explanations for how differences in construction material affect rates of rotation. Also formulate possible explanations for how differences in release height affect rates of rotation.

Assessment/Evaluation

Students should be evaluated on the collection and organization of data, calculation performances, and conclusion responses.

Resources/References

Trinklein, Frederick E. "Rotary Motion " *Modern Physics",* Holt, Rhinehart and Winston. Austin TX 78741, 1990.



Gyrocopters – Describing Rotary Motion

Name ______________________

Launch Height (m) ________________

Gyrocopter	Modification /Description	Number of Revolutions (Angular Displacement) (sec)	Direction of Spin	Descent Time (sec)	Direction of Angular Velocity	Average Angular Velocity		
						Rev/ sec	Rev/ min	Rad/ sec
1								
2								
3								

Launch Height (m) ________________

Gyrocopter	Modification /Description	Number of Revolutions (Angular Displacement) (sec)	Direction of Spin	Descent Time (sec)	Direction of Angular Velocity	Average Angular Velocity		
						Rev/ sec	Rev/ min	Rad/ sec
1								
2								
3								

Background:
There are various types of motion such as linear, free-fall, projectile, circular and rotary. Though each is distinctively different, all can be described in terms of displacement, velocity and acceleration. When it comes to rotary motion, it is described in terms of angular displacement, angular velocity and angular acceleration. Angular displacement is the angle about the axis of rotation through which the object turns and can be expressed in the units of revolutions, degrees or radians. Angular velocity is defined as the time rate change in angular displacement. Angular acceleration is the constant rate in change of angular velocity. Eve though the equations for each type of motion are specific, the basic means of description remains the same.

Materials: gyrocopters, pencil, paper, metersticks or metric tape measure, calculators, stopwatches

Safety Instructions: Follow all pre-established lab safety guidelines and expectations.

Procedure:
A. Pre-Activity
- Review briefly the equation for calculation angular velocity
- Review unit conversion factors between revolutions, degrees, and radians
- Obtain the three gyrocopters from the previous lesson extensions made of different materials but of the same size.

B. Activity
- Lab partners are to select a set release height for the gyrocopters and record it in the unit of meters.
- One partner is to release the gyrocopter from the selected height and count the number of revolutions or spins the gyrocopter undergoes and it "falls" to the floor. The number of spins is to be recorded as the "angular displacement" in the unit of revolutions. Repeat this step three times for each of the three gyrocopters.
- The other partner is to record the total time of the gyrocopters descent from the moment it is released until it touches the floor. Record this time in the unit of seconds.
- Noting the direction of spin for each gyrocopter, apply the "right-hand" rule to determine the direction of the angular velocity
- Calculate and record the magnitude of the average angular velocity for each of the three gyrocopters in the unit of revolutions per second.
- Perform unit conversions from revolutions per second to evolutions per minute and radians per second.
- Vary the release height for the gyrocopters at least twice, repeating steps 2-6 with each variation. Be sure to record the heights chosen again in the unit of meters.

C. Post-Activity
- Analyze all recorded observations, collected data, and calculations.
- discuss and compare results with other lab groups.
- Write a conclusion based on the analysis of your results. Within your conclusion compare and contrast calculated average angular accelerations for each gyrocopter. Formulate possible explanations for how differences in construction material affect rates of rotation.

- Also formulate possible explanations for how differences in release height affect rates of rotation.

Assessment/Evaluation:
Students will be evaluated on the collection and organization of data, calculation performances, and conclusion responses.

Resources/References:

Trinklein, Frederick E. "Rotary Motion." *Modern Physics,* Holt, Rhinehart and Winston. Austin TX 78741, 1990.

Delta Dart and the Computers

Grade Level: 11-12 **Subject Area**: Physics

Time Required
Preparation: 1 hour
Activity: 5 hours

National Standards Correlation:
Science (grades 9-12)
- History and Nature of Science Standard: Nature of scientific knowledge.
- History and Nature of Science Standard: Science as a human endeavor.
- Unifying Concepts and Processes Standard: Evidence, models, explanation.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Unifying Concepts and Processes Standard: Systems, order, and organization.
- Science as Inquiry Standard: Understandings about scientific inquiry.
- Physical Science Standard: Motions and forces.
- Science and Technology Standard: Understandings about science and technology.

Summary
In this lesson, students will study the forces that control flight and the three axes of motion using a NASA CD-ROM. They will then test the effect of adding control surfaces, i.e., ailerons, rudders and elevators (small post-it notes) to a plane to determine their effect on a planes motion. They will then verify their observations using the CD ROM.

Objectives
Student will:
- Define the four forces that affect flight.
- Describe the three axes of flight motion.
- Construct a model plane for observations.
- Design an experiment to test the effect of adding a rudder, ailerons, and elevators to a plane.
- Verify that the rudder controls yaw, the elevators control pitch, and that the ailerons control roll.

Background
Four forces are responsible for the flight of an airplane. The force of gravity pulls the plane toward the Earth. The lift force lifts it in the air. When these two forces are equal, the plane travels at a constant altitude. The thrust force (provided by the plane's engines) pushes the plane forward, while the drag force caused by air resistance pulls it back. When these two forces are equal, the plane travels forward at a constant velocity.

An aircraft has three types of motion. Yaw is when a plane turns to the left or right. This motion is controlled by the rudder on the tail of the plane. Planes can also point at different angles in the air.
This motion is called pitch and is controlled by the plane's elevators. Planes can also roll to either side. This motion is controlled by the ailerons located on the plane's wings.

Materials
- NASA's Exploring Aeronautics CD ROM (available from NASA CORE)
- Mac or PC's for each pair of students
- Delta Dart Plane Kit (available from Civil Air Patrol) or comparable model plane

- Elmer's Glue
- Tacking Glue
- Exacto Knives
- small post-it notes

Procedure

A. **Days One - Explore the CDROM**

Have students insert the CDROM into their computer. The program should begin automatically. Then have them click the airplane on the runway to begin the section entitled "How An Airplane Flies." They should work through this section of the CD with the intent of learning the answers to 3 questions.

1. What are the four forces affecting flight?
2. What causes lift?
3. What are the 3 axes of motion?

B. **Day Two - Model Construction**

Students should follow the directions specific to the model plane purchased. Depending on the level of the student you may want to walk them through the steps or you may choose to have them follow them. In either case, it is helpful if you have a model constructed for students to observe.

If constructing the Delta Dart model, stop after the wings are attached and allow the plane to dry overnight before proceeding.

C. **Day Three & Four - Fly Planes, Design & Execute Experiment**

Allow students to fly planes at least once without making modifications.

Demonstrate the use of post-it notes as rudders, ailerons, and elevators.

Have students design and conduct an experiment to determine which axes of motion is affected by each addition. Emphasize the control of variables. If time allows have them also determine the effect of putting the rudders, ailerons, and elevators in different positions.

D. **Day Five Wrap-Up**

Have students return to the CD-ROM. They should verify their results by using "The Resource Center" to determine the actual function of each control surface.

Assessment/Evaluation

Students should be evaluated on their ability to control variables in their experiment design and their accuracy in determining control surface function.

Resources/References

Wegener, Peter P. *What Makes Airplanes Fly?: History, Science, & Applications of Aerodynamics.* New York: Springer-Verlag New York, Inc., 1997

Summary
Students will conduct four activities using simple materials to demonstrate Bernoulli's Principle, the concept of lift as a force in flight, and angle of attack. Students will make predictions and record results. During this lesson, students will learn about Bernoulli's Principle and lift.

Balancing Acts

Grade Level: K-1 **Subject Area**: Science

Time Required (for each of three activities)
Preparation: 20 minutes
Activity: 30-45 minutes

National Standards Correlation
Science (grades K-4)
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.

Objectives
Students will:
- Make observations
- Balance various objects
- Predict why objects balance
- Discuss successes and failures

Lesson 1

Materials
- *Just a Little Bit* by Ann Tompert
- a 4 foot piece of 2" x 4"
- small boards and fulcrum
- small wood blocks

Safety Instructions
Use common sense precautions. Place 2" x 4" board on the floor so that each student is walking on the widest side. "Spot" children as necessary.

Background
Balance is produced by the even distribution of mass on each side of an axis. Symmetry is when size, shape and relative position of parts on opposite sides of a dividing line are equal or are mirror images.

Procedure
A. Warm Up
1. Read the story *Just a Little Bit* by Ann Tompert.
2. Introduce the word *balance*. Ask, "How did the see-saw balance?"

B. Activity I

1. Teacher demonstrates balance using board, fulcrum and blocks. Use correct vocabulary throughout all activities.
2. Children make predictions about the number of blocks needed to balance.

C. Activity II

1. Children take turns walking on the 2" x 4" board.
2. Encourage students to walk with arms in various positions to see which is easier.

D. Wrap up

1. Discuss information gained from walking on the board.
2. Relate information to the story and discuss that both sides must be equal in order to balance, both arms outstretched, both arms pulled in.

Assessment/Evaluation

Students will be evaluated on the accuracy of observations, use of correct terms, and participation in activities.

Extensions

1. Use other toys to demonstrate balance.
2. Put students with a buddy. Tell them to put their feet together and hold hands. Lean back, extend arms and balance. Be very careful. Try to stay standing.

Lesson 2

Materials

- bicycle with training wheels
- tricycle
- objects to balance—books, pencils, rulers, blocks or other objects found in classroom.

Safety Instructions

Use common sense precautions. Spot children on bicycle and tricycle. Non participants will stay seated for bicycle demonstrations.

Background

Balance is produced by the even distribution of mass on each side of an axis. Symmetry is when size, shape and relative position of parts on opposite sides of a dividing line are equal.

Procedure

A. Warm Up

1. Discuss and review the concept of balance. Note: this activity might be more easily conducted outside.

B. Activity I

1. The teacher will ask several children to demonstrate riding a bicycle and tricycle. Ask about the differences between the two bikes.

2. Predict what would happen if a training wheel was removed from the bicycle. Has this ever happened to any student?
3. Discuss predictions, outcomes and relate to balance and symmetry.

C. Activity II
1. Children will explore the concept of balance by balancing objects such as books, pencils, and blocks on various parts of their bodies.
2. Challenge the children to balance a book on their hand or head. Class will think of other ways to balance.
3. Children will share ideas during exploration. How are these balancing acts like the bicycle? How are they different?

D. Wrap Up
1. Children will share their successes and failures.

Assessment/Evaluation
Students will be evaluated on their demonstration of successfully balancing various objects.

Lesson 3

Materials
- variety of kites for discussion
- 8 1/2" x 11" paper cut in Eddy Kite shape (diamond)
- string - 10 inch and 24 inch - for each student
- crayons and markers
- crepe paper or tissue paper strips
- stapler or tape
- chart paper
- *Curious George Flies a Kite* by Margaret and H.A. Rey

Safety Instructions
Use common sense precautions throughout the lesson.

Background
Balance is produced by the even distribution of mass on each side of an axis.

Procedure
A. Warm Up
1. Read *Curious George Flies a Kite*
2. Review balance and symmetry.

B. Activity I
1. Show several kites, e.g. Sled and Eddy (diamond)
2. Discuss and show lines of symmetry.

C. Activity II

1. Children will make small paper Eddy (diamond) kites by following steps 2 – 7.
2. Fold the paper in the middle to create a line of symmetry. Students should balance the kite on their fingers.
3. Children use crayons and markers to decorate the kite. Explain to the children that the kite must be balanced. Both sides of the kite should look the same.
4. Tape tissue paper on bottom for tail.
5. Tape or staple a ten-inch bridle onto the sides of kite.
6. Tie 24 inches of string in a loop around the bridle.
7. Children will pull kite around room. All children should move in the same direction.
8. Discuss how a kite is like an airplane. How is it different?

D. Wrap Up

1. Students will brainstorm and teacher will list on chart paper things that balance in our everyday lives.

Assessment/Evaluation

Students will be evaluated on their ability to demonstrate symmetry while decorating their kites.

Extensions

1. Team with an older/buddy class to make sled kites—fly outside.
2. Fly demonstration kites and bring in other types of kites to share and fly.
3. Make paper airplanes—discuss symmetry and balance.
4. Show pictures of people using balance in other cultures.
   - -carrying a load on head
   - -yoke and oxen
   - -carrying two buckets on stick across shoulders
   - -acrobats or circus balancing acts
5. Demonstrate or make model airplanes and gliders.

If Peter Pan Can Fly, Why Can't I?

Grade Level: 2-6 **Subject Area:** Science

Time Required
Preparation: 1 hour
Activity: 1 hour every day for three days

National Standards Correlation
Science (grades K-4)
- History and Nature of Science Standard: Science as a human endeavor.
- Unifying Concepts and Processes Standard: Systems, order, and organization.
- Unifying Concepts and Processes Standard: Evidence, model, and explanation.
- Life Science Standard: Characteristics of an organism.
- Life Science Standard: Organisms and environments.
- History and Nature of Science Standard: Science as a human endeavor.
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.

Science (grades 5-8)
- Unifying Concepts and Processes Standard: Evidence, models and explanation.
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.

Summary
In cooperative learning groups students will investigate and classify a group of animals first generally and then specifically into fliers, gliders, and ground animals. Students will list characteristics that each of these groups have in common. After researching the characteristics of flying animals each group will redesign a human being so he/she can fly.

Objectives
Students will:
- Classify animals into groups of fliers, gliders, and ground animals.
- Develop a list of characteristics each group has in common.
- Research the adaptations animals have made in order to be able to fly.
- Redesign a human, using the data gained in research, so that he/she can fly.

Background
See Principles of Flight Introduction as well as the selections by Darling, Lopez, Taylor, and West listed in Resources/References.

Materials:
- pictures and plastic models of animals that include, but should not be limited to: swans, geese, robins, eagles, ducks, bats, flying lizards, flying fish, sea gulls, dragon flies, bees, pterodactyls, mosquitoes, butterflies, dogs, cats, lions, giraffes, elephants, horses, bears, snakes, sharks, turtles, frogs, owls, star fish, sponges, worms, etc.
- worksheet numbers 1, 2, and 3.
- pencils
- crayons and markers
- scissors

- construction and tissue paper
- pipe cleaners
- clay
- tooth picks and styrofoam
- ribbons, buttons, and scraps of material
- tape or glue

Procedure

A. Warm Up

1. Students should work in groups of three or four.
2. Give each group a collection of plastic animals and pictures. Instruct students to group the animals according to any criteria they select, and complete the animals worksheet as a team.
3. After the groups have completed their classifications and worksheet, select one student from each group to explain what criteria were selected and how the animals were classified.
4. Allow other groups an opportunity to ask questions or challenge any of the classifications.
5. Then ask students to reclassify their animals into three groups 1.) fliers 2.) gliders, and 3.) ground animals using **the chart.**
6. After the groups have completed their classifications, have a different person present the group's findings to the class.
7. Again, give other groups the opportunity to question or challenge.

B. Activity

1. On Day 2, have students conduct research on animals that can fly and animals that can glide and why. A variety of resources, such as videos and web sites, as well as books and reference materials should be used.
2. On Day Three, have students use the information they collected to redesign a human so that he/she can fly. There must be a written description and justification for each change and adaptation made. Students also need to include a model of their flying human. This may be a poster, sculpture, diorama, mobile, or any design of their choice.
3. Have students present their "Flying Human" to the class.
4. Students should then complete the evaluation form and have a conference with their instructor.

C. Wrap-Up

1. Students may wish to do one of the following:

    -Present their "Flying Human" at a parent open house.
    -Present their "Flying Human" to another class or a special teacher.
    -Make a video tape of their "Flying Humans."
    -Invite some pilots to critique their "Flying Humans."

Assessment/Evaluation

Use Team Evaluation

Extensions

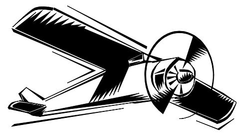
1. Design a game that would teach the principles of flight you learned in this unit.
2. Write a children's book about animals that fly.

3. Investigate myths on "How Birds Learned to Fly." Then write a myth of your own.

Resources and Reference

Darling, David J. *Up, Up and Away: The Science of Flight.* New York: Dillon Press, 1991.
Lopez, Donald. *The Nature Company Discoveries Library: Flight.* Time-Life Books, 1995.
Taylor, Barbara. *Up, Up and Away! The Science of Flight.* New York: Random House, 1992.
West, Ruth. *Why Does It Fly?* Mystic Island, New Jersey, 1994.
Vertebrate Adaptations. Scientific America, W. H. Freeman & Co. 1952.

Circle the animals that can fly. Name ______________________



IF PETER PAN CAN FLY, WHY CAN'T I?

NAME____

GROUP NAME____

LIST THE ANIMALS BY TYPE:

FLIERS	GLIDERS	GROUND ANIMALS

Team Evaluation

1. What references did your team use?

2. What did you learn about adaptations animals make to fly?

3. What contributions did you make to your group?

4. How did your group work together? If there were problems, what were they?

5. What did you like about working with your group?

6. What did you dislike about working with your group?

7. What do you think you did well in your project?

8. What difficulties did you have in your project?

9. How do you think your project might be improved?

Air Lift

Grade Level: 3 **Subject Area:** Science

Time Required
Activity: 10 – 20 minutes

National Standards Correlation
Science (grades K-4):
- History and Nature of Science Standard: Science as a human endeavor.
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Science as Inquiry Standard: Understandings about scientific inquiry.

Summary
Students will use only their breath to separate and lift one styrofoam cup out of another.

Objectives
Students will:
- Successfully use only their breath to separate and lift one styrofoam cup out of another.
- Predict, test, and observe the results of their experiments.
- Write predictions and observations in their science journals.

Materials (per student)
- 2 Styrofoam cups
- science journal or paper
- writing utensil

Safety Instructions: *Use common sense precautions.*

Procedure
A. Warm Up
1. Discuss with the students that air is made of many particles that can move at different rates.
2. Discuss with the students different examples of how air does work (kites, windmills, etc.).

B. Activity
1. Pass out two styrofoam cups to each student.
2. Have the students very lightly drop one cup into the other
3. Explain that the challenge is to separate the two cups without touching the two cups or dumping the top one out.
4. Have the students keep a record of what they are going to try and its results.
5. Provide 10 minutes for exploration.
6. If no one finds a solution, demonstrate this Bernoulli effect activity by blowing over the top cup. The top cup will lift up!

C. Wrap-up

1. Discuss with the class why the air will "lift" the top cup out of the bottom cup (moving air decreases the pressure).

Assessment/ Evaluation

Each student will describe (in paragraph form) what steps they took to remove the cup, using their science journals as reference.

Extensions

1. Place an object in the cup. Test to see if the cup can be lifted. Discuss why or why not.
2. Put a hole in one of the cups and explore the results.
3. Try the activity with cups of different sizes and materials.

Have a Ball with Bernoulli I

Grade level: 3 **Subject Area**: Science

Time Required
Preparation: 10 min.
Activity: 20 min.

National Standards Correlation
Science (grades K-4)
- Science as Inquiry Standard: Understandings about scientific inquiry.
- Physical Science Standard: Position and motion of objects.
- Physical Science Standard: Properties of objects and materials.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.

Summary
Students will construct and use a simple device to demonstrate Bernoulli's Principle that fast moving air has less pressure than slow moving air.

Objectives
Students will:
- Construct a tube and funnel device.
- Explore the effects of blowing air through the tube and the movement of a ball in reaction to the fast moving air.
- Explain how the reaction of the ball demonstrates Bernoulli's Principle.

Background
When you blow fast moving air under the ball, the ball wants to go up but the slow moving air above the ball pushes it back down causing the ball to stall and spin in mid-air. When you turn the funnel over with a ping-pong ball suspended in it then blow fast, the slow moving air exerts enough pressure to keep gravity from pulling the ball down.

Materials
- ping pong balls
- flex straws
- index cards or 3" squares of heavy paper

Procedure

A. Warm-up

1. Ask the class what would happen if you blew on the ball and how they could make the ball go up into the air using air. Ask the students what they know about the speed of air and air pressure.

B. Activity I

1. Students hold the ball over the short end of a straw bent into L shape and blow through to observe the reaction.
2. Students experiment to find a speed that will cause the ball to stall and spin above the straw in mid air.

C. Activity II

1. Cut a 3" circle from the index card.
2. Cut an 1 1/2" slit into the center of the circle.
3. Overlap the cut edges to form a funnel shape and glue or tape in place.
4. Cut off tip of funnel just enough for the straw to fit through.
5. Fit the straw into the bottom of the funnel and repeat activity one. (Note : You may need to secure the straw to the funnel with tape.) Now invert the funnel while blowing through the straw. (Make sure you take a very deep breath so as to sustain your blowing through this maneuver.) The ball should stay in the funnel. Several attempts may be needed to accomplish this feat. Students may record number of tries or seconds the ball stayed in the funnel.

D. Activity III

1. Students should make a sketch of air molecules and movement for the two activities above. use arrows as needed.

Wrap Up

Have students discuss the reaction of the ball in terms of Bernoulli's Principle. Describe conditions that were helpful and attempts that were unsuccessful and evaluate the causes and effects. Students then relate this knowledge to airplane lift.

Assessment/Evaluation

Students will be assessed on their ability to follow directions, their time on task through out the exploration and their ability to relate orally or in written form the relationship of the activity to principles of flight.

Extensions

1. Students can research Bernoulli and his experiments with air pressure.
2. Students can design and demonstrate other simple devices that illustrate Bernoulli's principle.

Have a Ball with Bernoulli II

Grade Level: 3 **Subject Area:** Science

Time Required
Preparation: 10-15 minutes
Activity: 1 class period, 30-45 minutes

National Standards Correlation
Science (grades K-4)
- Science as Inquiry Standard: Understandings necessary to do scientific inquiry.
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Physical Science Standard: Properties and changes in properties in matter.
- Unifying Concepts and Processes Standard: Evidence, models and explanation.

Summary
Students will predict, demonstrate, and observe the effects of air pressure.

Objectives
Students will:
- Predict the effect of moving water or air on air pressure
- Use a ping-pong ball and a stream of water to demonstrate an effect of lowered air pressure
- Use two cans to demonstrate an effect of air pressure
- Explore the power of wind
- Analyze the results of two activities and infer that moving air causes an area of lower pressure
- Identify common characteristics in the cause and effect of lowered air pressure, as stated in Bernoulli's Principle
- Write a paragraph comparing what happened in the two activities and the cause of those results

Materials
- ping-pong ball
- piece of string (8 cm)
- transparent tape
- sink with a faucet
- 2 empty soft-drink cans for each student
- ruler for each student
- drinking straw for each student

- data recording sheet or individual student journals

Safety Instructions: *Be sure that students do not share straws. Have extra straws on hand so all students can have his/her own.*

Background

Daniel Bernoulli was a mathematician who lived about 200 years ago. He was born in 1700 and died in 1782. He came from a family of mathematicians in Switzerland and was probably the most famous mathematician in the family. He published *Hydrodynamics* in 1738, in which he stated what is now called Bernoulli's Principle: As the speed of a fluid (liquid or gas) increases, its pressure decreases. He studied how wind affects objects. Through his experiments, he learned some very interesting facts about why things fly. We will do similar experiments to find out more about wind and flying.

Procedure

Warm up

1. Share with the class the previous information included in Background.
2. Before doing the "Have a Ball" activity, tell students step-by-step (Activity # 1 in part B below) how the activity will proceed.
3. Have students write predictions of what will happen in individual student journals or on data recording sheets.
4. Allow students to share predictions with the class.

Activity #1

1. Have students conduct this experiment as a whole class activity.
2. Tape the string to the ball.
3. Turn on a faucet, and let the water run fast.
4. Have students hold the string and ball as close as possible to the stream of running water without letting the ball touch the water. You may want to repeat this step several times allowing students to take turns.
5. Have students record observations in student journals or on data recording sheets.
6. Discuss observations. Lead students to realize the ball moved toward the stream of water because an area of lower pressure was formed near the rapidly moving water, causing the ball to be "drawn or pulled" in.

C. Activity # 2

1. Have students work individually on this activity.
2. Place the cans on their sides about 3 cm apart.
3. Blow air between the cans through the straw.
   (Note: the cans will come together more dramatically if students hold the straw parallel to the table.)
4. Place the cans 2 cm apart. Blow between them through the straw again.
5. Place the cans 1 cm apart. Blow between them one more time.
6. Record observations in student journals or on data recording sheets.
7. Ask these questions:

- What happened when you blew between the cans?
- How did the effect change as you moved the cans together?
- Why do you think the cans acted as they did?
- What does the low air pressure between two objects cause them to do?
- What would happen to two objects if the air pressure between them were high instead of low?

Wrap Up

1. Have students write a paragraph comparing what happened in the two activities and the cause of those results. Students may include illustrations in the form of drawings or diagrams.
2. Students may place the paragraphs in their science portfolios.

Assessment/ Evaluation

Listen to student remarks during discussions to see if their predictions and observations demonstrate an understanding of the effects of air pressure. Ask questions to check for understanding. Check summary paragraphs and illustrations.

Extensions

1. Use your observation from this activity to explain how the wind might affect things that fly.
2. Explain how the speed of wind affects air pressure.
3. Design a demonstration to show how the speed of wind affects air pressure.

Resources/References

Wings and Rockets, Harcourt Brace, pp. 23-25, 1995.

Flying Disc

Grade Level: 4 **Subject Areas:** Science and Math

Time Required:
Preparation: 1 hour
Activity: 40 minutes

National Standards Correlation
Math (grades 3-5)
- Measurement Standard: Apply appropriate techniques, tools, and formulas to determine measurements.

Science (grades K-4)
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.

Objectives
Students will:
- Record measurements
- Look for a pattern in own flight
- Compare flights
- Discuss variables

Material
- measuring devices (tape measure, meter stick etc.)
- orange cone or something to mark a starting point
- paper plates – the cheaper the better.
- masking tape
- scissors
- clipboard, paper, and pencils

Background
At one time, children threw tin pie plates at each other. Being metal objects, a safer disc was needed. Fortunately someone invented a plastic-flying disc that today is called a Frisbee®.

Frisbees® come in various sizes, generally defined by weight. A lighter disc will travel faster and be more maneuverable than a heavier one. A heavier disc, however, will be more stable, and travel farther than a lighter one. They come in all different colors and sizes.

Procedure
Warm-up
1. Discuss the information given in the first three paragraphs of Background.
2. Discuss different ways to measure distance i.e., meters, yards, feet, or counting off using their feet, etc.
3. Discuss factors that can affect the flight of a Frisbee® (wind, weight, etc.).

Activity

1. Have students create a flying disc by following these steps:
   a. Give each student a stack of 4-5 paper plates. The best way is to not pull apart the plates, but just give each student what is in the stack.
   b. Take one plate off the stack and set it aside.
   c. Cut the center out of the remaining stack of plates.
   d. Put the first plate back on the bottom.
   e. Using masking tape, tape around the edges to hold all the plates together.
   f. After a demonstration, have each student gently try to fly their disc in the classroom before moving to a larger area.

2. Find an area with enough room to fly the disc. Mark off a starting point so that you have accurate measurements to compare. (Take extra rolls of masking tape with you to create variables and also clipboards, paper and pencils to record flight measurements).
3. Have students work with a partner. One will fly while the other records distance flown. Have all students start flying at the same time to avoid risk of injury.
4. Once all students have flown their disc two times, have them gather around to discuss how they could make the disc go a shorter or longer distance.
5. After all students have tested a variable, return to class for discussion.

Wrap-Up

1. Have students share their observations after they have created a chart with their information.
2. List the distances traveled by the flying discs on the board and compare.
3. Have students identify variables they think affected the flight. Encourage students to look for patterns in the flight of their disc as well as those of their classmates.
4. Review Bernoulli's Principle (see background information in this section).
5. Conclude with journal writing. Be sure students explain their observations and include measurements.

Assessment/Evaluation

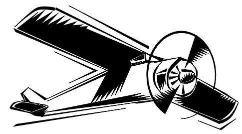
Use student charts and journal writings to evaluate understanding of the activity and to be sure that objectives were met.

Extensions

1. Make discs of various masses or sizes and compare flights to previous activity.
2. Play games with the flying disc (golf, softball, pickle, relay races, etc.).
3. Decorate the flying disc.
4. Have students explain how the disk is like an airplane wing and how it is different.

Resources/References

Frisbees (Internet search), http://bvsd.k12.co.us/~/hendrya/Disc.html
How Things Work: Balls, Birdies, and Frisbees (Internet search)
http://landau1.phys.virginia.edu/Education/Teaching/HowThingsWork/balls_birdies_frisbees.html
Frisbees Replace Hubcaps (Internet search)
http://www.lps.org/schools/hs/lse/publications/clarion110397/frisbees-replace-hubcaps.html



Comparison of a Bird Wing with an Airplane Wing

Grade Level: 3-4 **Subject Area:** Science and Math

Time Required
Preparation: 30 minutes
Activity: 2 hours

National Standards Correlation
Science (grades K-4)
- Unifying Concepts and Processes Standard: Systems, order and organization.
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.

Math (grades 3-5)
- Measurement Standard: Understand measurable attributes of objects and the units, systems, and processes of measurement
- Measurement Standard: Apply appropriate techniques, tools, and formulas to determine measurements.
- Data Analysis and Probability: Develop and evaluate inferences and predictions that are based on data.

Summary
Students will discover how the shape of a bird's wing indicates the type of flight that the bird uses. The student will then match a silhouette of a bird's wing with the wing of a type of aircraft and infer what type of flight the aircraft was designed for.

Objectives
Students will:
- Understand how the shape of a bird's wing is related to the type of flight the bird uses.
- Make a life sized silhouette of a bird with the correct length and wing span and shape.
- Understand that aircraft wings were modeled after a bird's wing in nature.

Materials
- large pieces of paper (like those used for a bulletin board)
- rulers, yardsticks, or meter sticks
- pencils and markers
- bird and airplane silhouettes

Background
Birds have three major forms of flight. Birds that fly short distances with maneuverability have short, wide, bent wings. Birds that soar on air currents for long periods of time have long, narrow wings that enable them to stay in the air without exhausting themselves. Long distance fliers have broad, long wings that they do not need to flap very fast to produce flight. Aircraft designers have mimicked these designs. A jet fighter that needs to fly fast and be highly maneuverable has short, broad wings like a swallow. A long distance bomber or cargo plane has long, broad wings like a goose. A glider has long, narrow wings like an albatross.

Procedure

A. Warm-up

1. Show the students a video of birds in different kinds of flight. After the video have discussion of what kind of behavior the birds used. Try to have the students use the words flapping, gliding, or soaring.

2. Show the students pages 10-12 in the book, How Does a Bird Fly by Usborne books. Read about the different wing shapes and the kind of flight they use.

B. Activity

1. Divide the students into pairs for partners.

2. Give each partner one or two bird silhouettes to make. This includes an outline shape of the bird and the dimensions.

3. The students are to draw the silhouette of the bird from above showing the correct length and wing span of the bird. They are to show the correct wing shape. On each silhouette the students should label the bird name and dimensions. They should also label one of three kinds of flight: long distance, soaring, or short distance-maneuverability. The bird silhouettes are to be cut out when finished and may be colored the appropriate color if the group has time. This makes a very striking wall display.

4. After the bird silhouette is finished, each pair is then given a sheet with plane silhouettes. They are to find a plane that has a similar wing shape as their bird. Each pair then researches the plane and completes a simple form about the aircraft. The students are to see that the type of flight that the aircraft was designed for is the same kind of flight that the bird uses. The report forms are hung near the bird silhouettes on the class display.

5. If the class has Internet access it is very simple to use the United States Air Force Museum web site for the aircraft research. After they have selected a matching shape, they can access the web site and get all the information needed about the displayed aircraft.

C. Wrap-Up

Each pair of students will share their silhouette of the bird and their aircraft report. They will emphasize the wing shape and corresponding kind of flight.

Assessment/Evaluation

Students may be evaluated on their ability to work cooperatively as members of a team to complete the task and on the accuracy of the measurements in the bird silhouette. The written evaluation may include a science journal entry that has to include the wing shape of their bird, the wing shape of the aircraft, and show an understanding of the corresponding type of flight.

Extensions

1. Make paper airplanes with the same kind of wing shape as the birds and see how their flight is affected.

Resources/References

Schmidt, Norman. Paper Birds That Fly. Sterling Publishing Co. Inc. New York, 1996.
Woodward, Kate. How Does a Bird Fly? Usborne Publishing Ltd. London, 1991.

Gyrocopter and the Scientific Method

Grade Level: 7 **Subject Area:** Science

Time Required
Preparation: 15-20 minutes
Activity: 1-2 class periods

National Standards Correlation
Science (grades 5-8)
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Science as Inquiry Standard: Understanding about scientific inquiry.
- Physical Science Standard: Motions and forces.
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.

Summary
Students will use a self-made gyrocopter and test different variables to correctly identify the steps of the scientific method. After the gyrocopter is constructed, the student will drop it from a chair several times. Students will change the direction of the blades to test one specific variable. The gyrocopter will be dropped again several times. Without realizing that the students are using the scientific approach to experimentation they will begin to understand the steps involved in the scientific method. At the end of the experiment with the blades, the students will then be able to change other variables such as mass, size of gyrocopter, material used to make the gyrocopter, etc.

Objectives
Students will:
- practice the scientific method
- learn to record observations after testing a variable in an experiment
- learn to make a hypothesis
- identify the difference between dependent and independent variables

Materials
- gyrocopter template
- pencil
- paper
- scissors

Safety Instructions
Use caution when dropping gyrocopters.

Background
A gyrocopter is a model of a helicopter. This simple model will allow students to

observe the direction in which the blades will spin, either clockwise or counter-clockwise, as it descends to the ground. This simple model will also help students identify the steps involved in carrying out a scientific experiment.

Procedure

A. Warm Up

1. Obtain a template page of gyrocopter.
2. Cut out a strip off of the template page (Figure 1).
3. Follow the outline of directions in Figure 2 for making cuts and folds for your gyrocopter.

B. Activity

1. Ask yourself "Which direction will the blades spin as it descends to the ground?"
2. Carefully stand on a chair and drop your gyrocopter. Notice the direction the blades spin as it falls to the ground. Repeat the drop three more times. Record your observations in the data and observation table (Figure 3).
3. Now refold the blades in the opposite direction as folded in the beginning. Drop the gyrocopter four more trials. Was there a change in the direction of the spin of the blades? Record your observations in the data and observation table.

C. Wrap-Up

1. You have just performed a simple experiment. Experiments involve changing something and then finding out if results have changed. You were looking at a <u>variable</u>. There are 2 types of variables, dependent and independent. (See glossary)
2. You also made a prediction about the direction of the spin of the blades. This prediction is called a hypothesis.
3. This experiment was considered a fair test because all variables but one were kept constant.
4. The experiment gave us reliable results because we tested our gyrocopters with repeated trials.
5. Experiment with gyrocopters of different mass, size, and material.
6. Answer the "Questions About Experiments" on the worksheet.

Assessment/Evaluation

Students will be evaluated on their observations and their responses to the questions about experimentation.

Resources

Cothron, H. Julia. Geise, N. Ronald, Rezba, J. Richard. "Come Fly With Us", *Science World*, December 7, 1990.

Hassard, Jack. *Increasing Your Student's Science Achievement: Using Outstanding Active Learning, Project Based, On-Line and Performance Assessment Strategies* (Grades 6-12), Institute for Educational Development, Medina WA, 1996.

Name ____________________

QUESTIONS ABOUT EXPERIMENTS

1. What do we call the variable that you change on purpose?

2. What do we call the variable that responds to the one that you changed?

3. What do we call the part of an experiment that you must keep the same in each trial?

4. What do we call the part of an experiment that is the standard for comparison?

5. What was your hypothesis for the gyrocopter experiment?

6. Why did you repeat this experiment for four trials?

7. What did you learn when other variables were changed?

Figure 1

Whirlybird Template

Copy this template to use with the whirlybird activity. Students can use these strips to cut and make whirlybirds out of different materials (newspaper, construction paper, file folders). Each strip is 2.5cm X 21.5 cm.

WB Special	WB Special	WB Special	WB Special	WB Special	WB Special	WB Special

Figure 2

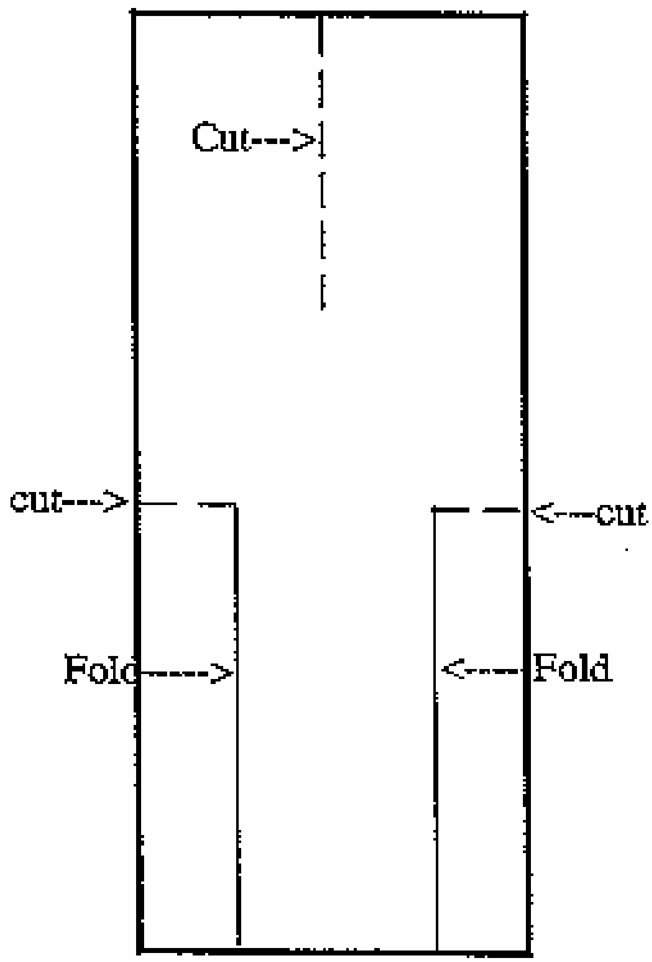
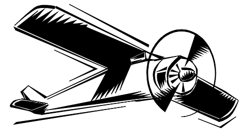


Fig. 1

Figure 3

Whirlybird Observations and Data

	One blade forward/One blade backward	Opposite fold of blades
	Direction of Spin	Direction of Spin
TRIAL 1		
TRIAL 2		
TRIAL 3		
TRIAL 4		



Aircraft and Scale

Grade Level: 7 **Subject Area:** Science and Math

Time Required
Preparation: 15 minutes
Activity: 2 – 3 hours

National Standards Correlation
Science (grades 5-8)
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.

Math (grades 6-8)
- Numbers and Operations Standard: Compute fluently and make reasonable estimates.
- Algebra Standard: Use mathematical models to represent and understand quantitative relationships.
- Measurement Standard: Apply appropriate techniques, tools, and formulas to determine measurements.

Summary
Students will use toy models of aircraft to explore the concept of scale. They will measure the dimensions of the model, compare those dimensions to the actual size of the aircraft, and then determine the scale. They will make an outline of the actual aircraft and compare it to the model. Finally, they will make an enlargement of an outline of their toy and give the scale factor.

Objectives
Students will:
- Make observations, make measurements, and collect data using model aircraft.
- Understand the meaning of scale.
- Use the scale factor and the toy to make an outline of the life-size aircraft.
- Use proportional reasoning to make an enlarged drawing of their toy.
- Work cooperatively in groups.

Materials
- rulers and calipers for measuring
- toy airplane or model for each group
- string
- graph paper

Background
A ratio is a comparison of two quantities that tells the scale between them. Ratios may be expressed as quotients, fractions, decimals, percents, or given in the form a:b. An example of a ratio like we use in this activity would be the ratio of the length of a side of a small figure or model to the corresponding side in a large figure where the large figure or real-life figure is 1/2. The ratio of the length of a side in the large figure to the corresponding side in the small figure is thus

2/1 or 2. The scale is the number a ratio is multiplied by to find an equivalent ratio. Scaling a ratio produces any number of equivalent ratios, which all have the same units and the same average distribution. The scale factor is the factor by which a picture or object is enlarged or shrunk. The scale factor may be expressed as a fraction, decimal, or percent.

Procedure

A. Warm Up

1. Conduct a discussion about scale. Use maps or various toys that have the scale marked on them.
2. Discuss what scale means and how they would find out the size of the real-life objects or how far a place is in real life compared to a map.

B. Activity

1. Give each group a die cast metal model of an airplane. Have students make any observations about the writing on their toy and what it means. (You may not find the scale on models of airplanes that are die cast metal models.)
2. Have students measure the critical dimensions of their aircraft. These include length, wingspan, and height. They could also include any other distinguishing dimensions for their toy, such as tail width, propeller length, wheel diameter, and any other part the group agrees to measure. Students may need guidance in getting accurate measurements. Inexpensive calipers may be helpful to use to get accurate measurements. Record the data.
3. Students should predict what the actual dimensions are for the things that they measured on their aircraft. Then they need to determine the size of the life-size aircraft by doing research. The United States Air Force Museum web site will be helpful in finding some of this information.
4. Students should determine how many times bigger the toy would need to be to become life-size or how many times bigger the life-size aircraft is than the toy (scale factor). Have students see if the scale factor is the same for all dimensions.
5. Give each group string and go to a big enough space so that students can use what they have learned to make an outline of the life-size aircraft. They can use actual measurements or they can use the toy by laying it end to end the scale factor number of times.
6. Provide students with graph paper. Have them make an outline of their toy on the graph paper. Tell them that they need to figure out a way to enlarge their outline by 2, 3, 4, times, or whatever you determine it should be. You might let the groups decide how much to enlarge it.

C. Wrap -Up

1. Make a comparison of the collected data from each group. Compare the scale for each toy.
2. Display each of the enlargements. Have each group show their toy and give the scale factor that they used.

Assessment/Evaluation

Ask students to explain the following:

- What procedure did you use for making your enlargement?
- What is meant by the scale factor?
- How did you use the scale factor in this project?

Extensions

1. Students could research their aircraft and be ready to share with the class interesting facts such as when it was used and what missions this type of aircraft participated in.

2. Have a discussion about weight and scale. If you know the actual weight, could you calculate what the model should weigh using the scale? (*No, scale is linear and weight includes volume.)* If you weigh the model and you know the actual weight, can you figure out a scale factor? *(No, you have to consider materials used. They would not be the same for the toy and the real-like aircraft.)*

3. Taking the height of an average man or woman, figure out how tall a model of a person would be to be a pilot for the toy.

Classify Machines That Fly!!!

Grade Level: 8 **Subject Area:** Science

Time Required
Preparation: 15 minutes
Activity: 60 minutes

National Standards Correlation
Science (grades 5- 8)
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.
- Unifying Concepts and Processes Standard: Systems, order and organization.

Summary
Students will design their own dichotomous key for the eight airplanes given. After students have designed their keys they will exchange papers and check each other's keys for accuracy.

Objectives
Students will:
- Learn the definition of a dichotomous key
- Classify objects into groups
- Make a dichotomous key

Materials
- pencil
- paper
- handout of the different aircraft to be classified
- diagram for dichotomous key

Background
To classify means to group objects by their similarities and/or their differences. A dichotomous key is used to classify things by dividing a group into two by characteristics. First, the group is divided into two parts. Next, each of those parts are divided again. This process continues until the groups are single objects. Dichotomous keys are very helpful in studying how to classify objects with numerous characteristics. The key is then used to identify individual objects.

Procedure
A. Warm Up
1. Discuss the different types of aircraft. An aircraft is given a two-part symbol consisting of a letter and a number. There are several types of aircraft and 3 types are used for this activity. These are:

B (Bomber)   They are designed to carry bombs, torpedoes or missiles.
C (Cargo)   They carry cargo or passengers.
F (Fighter)   They are designed to intercept and destroy other aircraft or missiles.

2. The number tells the model of the aircraft.
   For example: (F-16) a fighter plane with the model number of 16
   (F-16C) a newer version of the original F-16
3. Have students review what the symbols stand for.

Activity
1. Have students study the pictures of the aircraft.
2. Direct them to divide the aircraft into 2 large groups. Write the characteristic of one group on the top line of the diagram and the characteristic of the other group on the bottom line. Refer to Figure 1. Often, the second characteristic is "no" of the first characteristic.
3. Divide the top group into 2 more groups. Write the characteristics on the lines. See Figure 1.
4. Divide the group into 2 more groups and write the characteristic of the groups on the lines. Do the same for the other group.
5. Then tell students to start with the bottom group, and follow the above procedure for the remaining aircraft.

Assessment/Evaluation
Students may exchange papers and see if they can follow each other's dichotomous keys.

Extensions
The information from the dichotomous key can be put into column form to use as a key to check answers.

A.______________________________ ____________________
B.______________________________ ____________________

C.______________________________ ____________________
D.______________________________ ____________________

E.______________________________ ____________________
F.______________________________ ____________________

G.______________________________ ____________________
H.______________________________ ____________________

I.______________________________ ____________________
J.______________________________ ____________________

K.______________________________ ____________________
L.______________________________ ____________________

M.______________________________ ____________________

N.______________________________ ____________________

In the left column, write the characteristics used to divide each group. In the right column, write "Go to" clues. These clues will tell someone using the key where to go to search for the names of the aircraft.

Resources/References

The National Museum of the United States Air Force web site: http://www.wpafb.af.mil/museum/

Figure 1:

E.__________

C.____________

F.___________

A.____________

G.___________

D.____________

H.___________

All Aircraft

K.___________

I._____________

B.____________ L.____________

M.____________

J._____________

N._____________

EXAMPLE OF DICHOTOMOUS KEY

rectangular tail, B-24

4 propellers on front of wings

Bombers no rectangular tail, B-29

6 props on back of wing, B-36

No propellers on front of wings

Aircraft Delta wing shape, B-58

Swept wing, F-86

Fighter aircraft

Not bombers "W" shape wing, F-117

4 propellers, C-124

Cargo aircraft

2 propellers, C-46

Example of Answer for Extension

A. Bombers	Go to C, D
B. Not Bombers	Go to I, J
C. 4 propellers on front of wings	Go to E, F
D. No propellers on front of wings	Go to G, H
E. Rectangular tail	B-24
F. No rectangular tail	B-29
G. 6 propellers on back of wing	B-36
H. Delta wing shape	B-58
I. Fighter aircraft	Go to K, L
J. Not fighter aircraft	Go to M, N
K. Swept wing	F-86
L. "W" shaped wing	F-117
M. 4 propellers	C-124
N. 2 propellers	C-46

Household Things That Fly and Why

Grade Level: 2-3 **Subject Area:** Science and Math

Time Required
Preparation: 1 hour
Activity: 2-3 hours

National Standards Correlation
Science (grades K-4)
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Unifying Concepts and Processes Standard: Evidence, model, and explanation.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Unifying Concepts and Processes Standard: Systems order and organization.

Summary
Students will become acquainted with the four "forces of flight" as they have fun flight-testing various objects commonly found around the house (such as Tupperware bowls, crackers, hats, and pie tins). Prior to test-flying the objects, students will predict whether or not they think the objects will fly and how far they think they will fly. Students will fly the various household objects, measure distances flown and record their observations in a flight log. As a culminating activity, each student will write a description of the flight of their favorite object, detailing the "forces of flight" at work.

Objectives
Students will:
- Learn the four "forces of flight"
- Predict which objects will fly and how far they will fly
- Measure and record the distance flown by each object
- Create a flight log of observations of each flight
- Describe their favorite flying object
- Explain how the "forces of flight" were at work during the various flights

Background
There are four "forces of flight" which act upon an object in flight:

Lift: the force that pushes the object up
Gravity: the force that pulls the object down (the opposite of lift)
Thrust: the force that pushes the object forward
Drag: the force that pushes against the object (the opposite of thrust)

Using the suggested household objects (listed in materials below), the Ritz cracker had no lift; however the thrust was greater than the gravity and drag. The Ritz cracker flew. The brimmed hat, ball cap, square plastic lid, round plastic lid, aluminum foil pie tin and small plastic bowl flew because lift and thrust were greater than gravity and drag. Gravity and drag were greater than lift and thrust, and the toilet paper roll and styrofoam plate did not fly as well as the other objects. Results will vary depending on the samples used.

Materials

- various household objects:
    - Ritz cracker or any round cracker
    - empty toilet paper roll
    - brimmed hat
    - ball cap
    - square plastic lid
    - round plastic lid
    - aluminum foil pie tin
    - round styrofoam dinner plate
    - small plastic bowl

- Test Objects worksheet for each student
- 3 Flight Log worksheets for each student
- butcher block paper and markers for making graphs
- tape measures (metric or standard)
- masking tape

Safety Instructions: *Use caution when flying the objects. Create a single direction flight zone. Be sure that students stop flying the objects when other students are retrieving objects that have already landed.*

Procedure

A. Warm-up

1. Explain and demonstrate the four "forces of flight" using a Frisbee or other familiar flying object.
2. Show the class the various household objects to be test-flown.
3. Give students Test Sample worksheets and have them predict which objects they think will fly. Predict how far objects will fly.
4. Create a class bar graph. On the horizontal axis of the bar graph indicate each object to be test-flown and on the vertical axis write, "Number of Students Who Think the Object will Fly". Complete the graph as a class.

B. Activity (In the gymnasium or other large indoor area)

1. Using masking tape, mark a line on one end of the gym floor. This will be the line that the student will stand behind when launching the objects.
2. Designate a student to be the "flyer" of the objects. The "flyer" stands behind the line and using a Frisbee-like throwing motion, "flies" each object (same "flyer" flies all objects).
3. A pair of students will place a piece of masking tape on the landing spot of each object, write the name of the object on the tape, and remove the object.

4. Each student will complete a flight log, which is a record of observations of each flight. Explain how the "forces of flight" affected each flight.
5. Place students into pairs. Using the tape measure, each pair of students will measure the distance flown by each object, and record that distance in their flight log.

C. Wrap-up
1. Students will compare flight logs and discuss which "forces of flight" were at work during each flight.
2. Create a class bar graph showing each object and the distance it flew.

Assessment/Evaluation
Each student will describe (in paragraph form) their favorite flying object. The description should include the "forces of flight" at work during the flight. Students should refer to their flight logs and the bar graph for information.

Extensions
1. Classify the objects. Possible categories are:
- objects that did not fly
- objects that flew
- objects that flew more than half the distance of the room
- objects that flew less than half the distance of the room

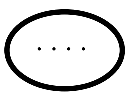
2. Test other household objects at home, complete a flight log, and report findings to the class.
Note: Students should have parental permission and supervision for home test flights.

Test Objects Worksheet

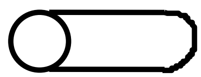
Household Things That Fly and Why

Name____

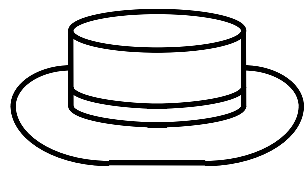
Directions: Circle the objects you think will fly.



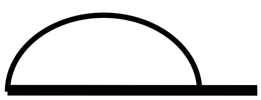
Ritz cracker



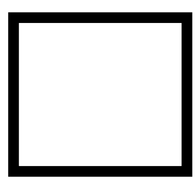
toilet paper roll



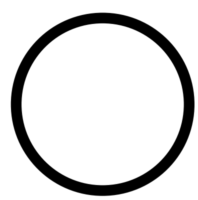
brimmed hat



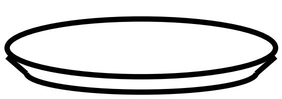
ball cap



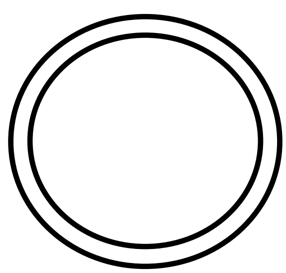
square plastic lid



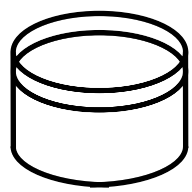
round plastic lid



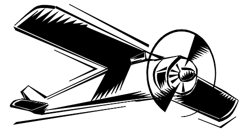
foil pie plate



styrofoam plate



small plastic bowl



Flight Log

Name____

Object:____________________________

Circle one:

Flew - The forces of Lift and Thrust were greater than the forces of gravity and drag.
Distance flown ______________________________

Didn't Fly - The forces of Gravity and Drag were greater than the forces of lift and thrust.

Object:____________________________

Circle one:

Flew - The forces of Lift and Thrust were greater than the forces of gravity and drag.
Distance flown ______________________________

Didn't Fly - The forces of Gravity and Drag were greater than the forces of lift and thrust.

Object:____________________________

Circle one:

Flew - The forces of Lift and Thrust were greater than the forces of gravity and drag.
Distance flown ______________________________

Didn't Fly - The forces of Gravity and Drag were greater than the forces of lift and thrust.

Object:____________________________

Circle one:

Flew - The forces of Lift and Thrust were greater than the forces of gravity and drag.
Distance flown ______________________________

Didn't Fly - The forces of Gravity and Drag were greater than the forces of lift and thrust.

An Uplifting Experience

Grade Level: 5 **Subject Area:** Science

Time Required
Preparation: 1 hour
Activity: 2 hours

National Standards Correlation
Science (grades 5-8)
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Science in Personal and Social Perspectives Standard: Science and technology in society.
- Physical Science Standard: Motion and forces
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.

Summary
Students will conduct four activities using simple materials to demonstrate Bernoulli's Principle, the concept of lift as a force in flight, and angle of attack. Students will make predictions and record results. During this lesson, students will learn about Bernoulli's Principle and lift.

Objectives
Students will:
- Build an airfoil
- Explain and demonstrate Bernoulli's Principle
- Explore the action of lift as a force in flight

Background
See Principles of Flight Introduction.

Materials

Activity I:
- each student will need a paper strip (4" x 11")

Activity II:
- 25 or more drinking straws
- 2 empty soda cans

Activity III:
- index cards (4" x 6")
- duct tape
- one drinking straw
- fishing line
- hair dryer
- table

Safety Instructions: *Use caution when operating the hair dryer--it can get very HOT!*

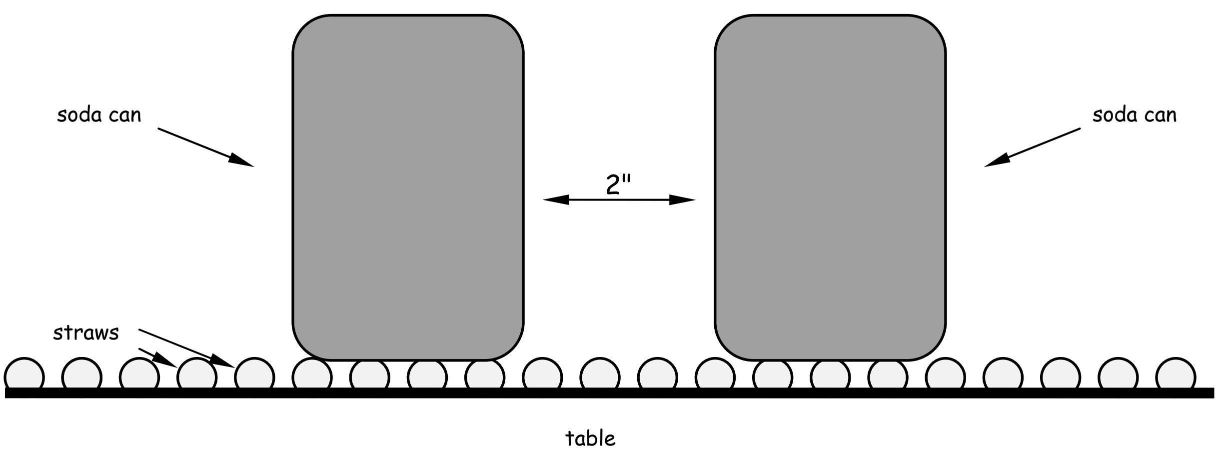
Procedure

A. Warm-up

1. Review Bernoulli’s Principle. Have students hold the short end of a strip of paper (4" x 11") at both corners. Students will hold the paper close to their mouths and blow forcefully across the top of the paper. The paper should lift.

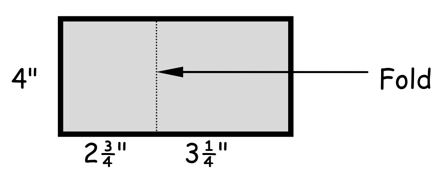
B. Activity I

1. Place 25 straws in a row on a tabletop, making sure the straws are very close together ($\frac{1}{4}$" apart).
2. Place two soda cans on top of the straws approximately 2" apart. The cans will be free to roll.
3. Predict what will happen when air is blown between the cans.
4. Blow between the cans, using a straw to blow air through. Bernoulli's Principle should be demonstrated when the cans move closer together.
5. Record results.
6. Experiment changing the distances of straws and cans. Predict and record results.

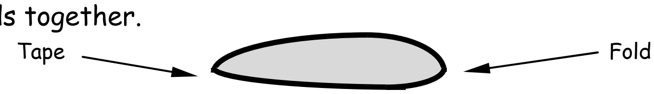


Activity II - Making an Airfoil

1. Review the concept of an airfoil (using information in background).
2. Fold a 4" x 6" index card in two, leaving an overlap of about $\frac{1}{2}$".

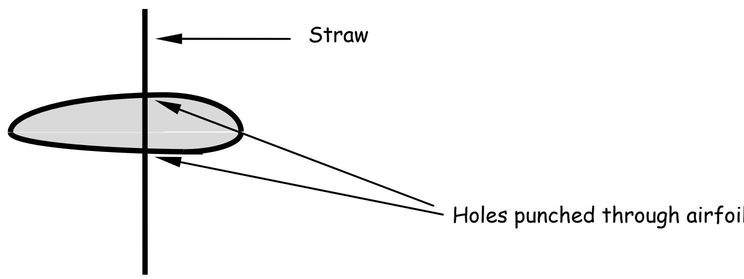


3. Push the overlapping ends together. One side of the folded index card will curve up.
4. Tape the ends together.

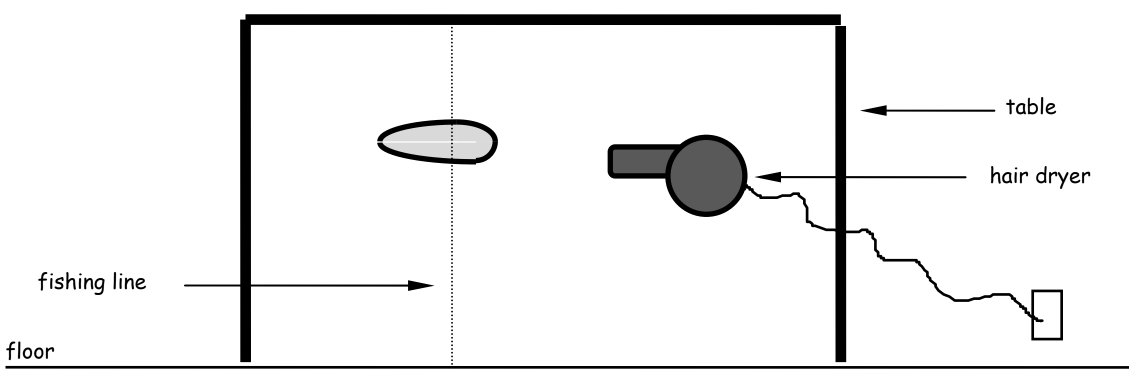


5. Use a pen to punch 2 holes through the middle of the airfoil (one hole on the top and one on the bottom).

6. Carefully push a drinking straw through the holes.



7. Pull a piece of fishing line through the straw. Cut the fishing line long enough to fit between the underside of a table and the floor. Hold the fishing line in place, making sure it is perpendicular (90°) to the floor and table.
8. Tape the fishing line in place between the table and floor. The airfoil should be able to slide freely up and down the line.
9. Lift the wing up slightly and aim the hair dryer at the folded edge.
10. Turn the dryer on. The wing should lift. Point the dryer straight for the best lift.



Activity III - Angle of Attack

1. Using the airfoil set-up from Activity II, experiment with angle of attack by moving the string to an 80° angle rather than 90° angle. Turn hair dryer on. Observe results.
2. Move string to 70° and 60°. Observe results.

Assessment/Evaluation

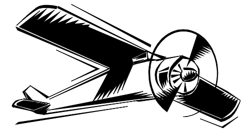
Students should be evaluated based on recordings of predictions and results of activities where applicable.

Extensions

1. Change the size and shape of the airfoils in Activity II.
2. Turn the airfoil upside down and test it again in Activity II.
3. Try to move the hair dryer further away in Activity II.
4. Research Daniel Bernoulli's life and present a report to the class.

Resources/References

Hetzel, June, and Wyma, Brenda. *Flight*. Cypress, California: Creative Teaching Press, Inc., 1995.
Hixson, B.K. *Bernoulli's Book*. Salt Lake City: The Wild Goose Company, 1991.
Johnstone, Hugh. *Aircraft and Space Rockets.* New York: Gloucester Press, 1989.
Robson, Pam. *Air, Wind, & Flight.* New York: Gloucester Press, 1992.
Taylor, Kim. *Flight.* New York: John Wiley & Sons, Inc., 1992.



Symmetry in Paper Airplanes

Grade Level: 5 **Subject Area:** Science and Math

Time Required
Preparation: 15 minutes
Activity: 2 hours

National Standards Correlation
Science (grades 5-8)
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Unifying Concepts and Processes Standard: Change, constancy, measurement.
- Unifying Concepts and Processes Standard: Evidence, models and explanation.

Math (grades 3-5)
- Geometry Standard: Use visualization, spatial reasoning, and geometric modeling to solve problems.
- Geometry Standard: Apply transformations and use symmetry to analyze mathematical situations.
- Measurement Standard: Apply appropriate techniques, tools, and formulas to determine measurements.

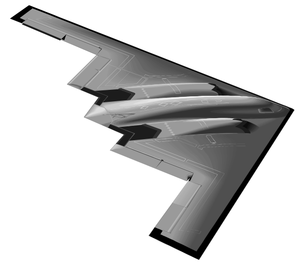
Summary
Students will design paper airplanes with middle line symmetry. The paper airplanes will not have any curved lines. They must have right, obtuse and acute angles. After the planes are designed, each designer will measure the angles. Students will exchange their paper airplanes with other students, and continue to practice measuring angles.

Objectives
Student will:
- Learn how to use line symmetry
- Identify right, obtuse and acute angles
- Use a protractor to measure angles

Materials
- white drawing paper
- protractor
- colored pencils

Background
Symmetry is defined as "beauty of form that arises from harmony of proportion." In other words, symmetry is a balance that is achieved through size, shape, position and even coloring of different parts on opposite sides of a middle line. Symmetry has always played an important part in history and in art. It was very important in the architecture of ancient Greece and the Italian Renaissance.

Procedure
A. Warm-up
1. Using white drawing paper, have students make a paper airplane, using any method of their choice. Designate one area of the room as a runway. Test fly the airplanes.



B. Activity

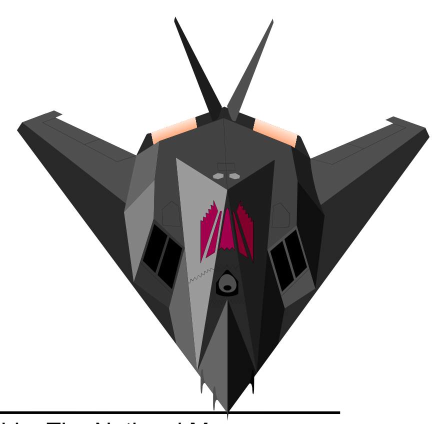
1. Ask," When designing and making the paper airplanes, what did you think about?" "Did you make the airplane symmetrical?" (Have a few examples of symmetry to show the class; so they have a good visual picture of what symmetry is).
2. Now instruct the class that you would like them to build another paper airplane. This airplane must not have any curved lines...only straight lines and angles. Be sure to use at least one acute angle, one right angle and one obtuse angle.
3. Decorate and color the planes symmetrically.
4. With a protractor, have students measure at least five angles on each airplane and record on a chart.
5. Have students trade paper airplanes, and continue to measure angles on other airplanes. Record angles measured.

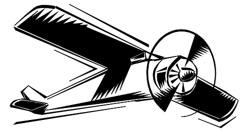
C. Wrap-up

1. Organize students into groups of 3 or 4. In each group students must choose one airplane to represent their group.
2. As a group, students will design an insignia and make a patch similar to the flight patches that military pilots and astronauts wear on their flight suits. Students may want to name their airplane, and include this on their flight insignia.

Assessment/Evaluation

Students will be evaluated on their ability to use a protractor correctly and measure angles accurately.





Paper Glider Measurement

Grade Level: 5-6 **Subject Area**: Math

Time Required
Preparation: 1 hour
Activity: 2-3 hours

National Standards Correlation
Math (grade 3-5)
- Measurement Standard: Apply appropriate techniques, tools, and formulas to determine measurements.
- Data Analysis and Probability Standard: Understand and apply basic concepts of probability.
- Data Analysis and Probability Standard: Select and use appropriate statistic methods to analyze data.
- Representation Standard: Use representation to model and interpret physical, social, and mathematical phenomena.

Math (grades 6-8)
- Measurement Standard: Apply appropriate techniques, tools, and formulas to determine measurements.
- Data Analysis and Probability Standard: Understand and apply basic concepts of probability.
- Data Analysis and Probability Standard: Select and use appropriate statistic methods to analyze data.
- Representation Standard: Create and use representations to organize, record, and communicate mathematical ideas.

Summary
Students (working in groups of 4) will construct four different paper gliders. After constructing the gliders, the students will estimate the distance they think the gliders will fly. Students will fly the gliders and calculate average distance flown. Next, the students will modify the weight of the gliders using paper clips, and again fly the four gliders and calculate average distances flown. They will record the distances flown and make a double bar graph, comparing the two flights of each glider.

Objectives
Students will:
- Follow directions to construct 4 different paper gliders
- Predict how far the gliders will fly
- Measure actual distances flown by each glider
- Calculate average distance flown by each glider
- Make a double bar graph

Background
See Principles of Flight Introduction.

Materials
Each group of four students will need:
- paper
- one set of 4 glider patterns (refer to selected bibliography)
- pencils
- measuring tape with metric units and/or meter sticks

- paper clips

Safety Instructions: Do not fly paper gliders directly at another person because the pointed tip could cause injury. Use caution when flying the paper airplanes. Create a single direction flight zone. Be sure that students stop flying their airplanes when other students are retrieving airplanes that have already landed.

Procedure

A. Warm up

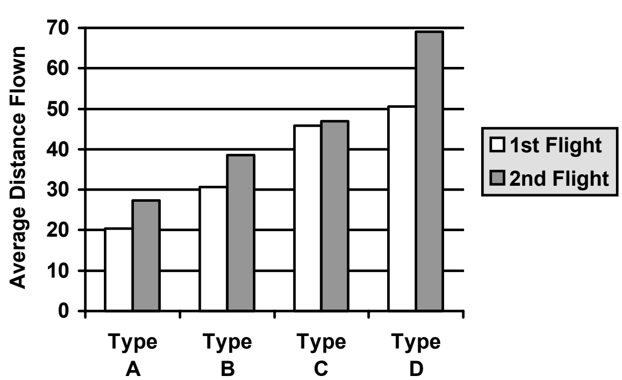
1. Give a brief lesson on the history of gliders.
2. Review how to correctly measure distance using a metric tape measure/meter stick.
3. Review how to calculate mathematical average.
4. Review how to complete a bar graph.
5. Find 4 different paper glider patterns to copy and give to each group of students.

B. Activity

1. Divide class into groups of 4 students. Give each group a set of glider patterns. Each group will construct a set of 4 different gliders.
2. Fly the paper gliders in a large open indoor area (such as the gymnasium). Instruct the students to make several practice flights before they start to record data so as to get the feel of how to throw a paper glider properly.
3. Each team will estimate how far they think each of the gliders will fly. Record estimation.
4. Now fly each glider 5 times. Measure distances flown. Record.
5. Calculate the average distance flown by each of the 4 gliders. Record.
6. Give each group some paper clips and allow them to modify the gliders by adding mass (paper clips) to the gliders.
7. Fly the modified gliders 5 times each. Measure distances flown. Record.
8. Calculate the average distance flown by each of the 4 modified gliders. Record.

C. Wrap up

1. Each group will make a double bar graph (example shown below) to represent the average distance flown by each glider during the first flight and the second (modified) flight.
2. Share graphs with the class and discuss results.



Assessment/Evaluation

Students will be assessed on their ability to follow directions, measure accurately, calculate averages correctly, make bar graphs, and work cooperatively as a team.

Extensions

1. Decorate gliders using crayons, markers, or colored pencils. Research World War II aircraft and decorate gliders to represent one of the planes.
2. Repeat the lesson using standard units when recording flight distances.
3. Research significant historical figures and events related to gliders. Write a report.
5. Write an editorial of the first manned glider flight.

Resources/References

Compton's Interactive Encyclopedia. Compton's NewMedia Inc., 1993.
Lopez, Donald S. *Aviation A Smithsonian Guide*. New York: Macmillan Company 1995.
The World Book Encyclopedia, Vol. 8, pp. 228-232, 1988.

Boomerangs Keep Coming Back

Grade Level: 7-8 **Subject Area:** Science

Time Required
Preparation: 30 minutes
Activity: 1 hour

National Standards Correlation
Science (grades 5-8)

- Science as Inquiry Standard: Understanding about scientific inquiry.
- Science as Inquiry Standard: Understanding about scientific inquiry.
- History and Nature of Science Standard: Nature of Science.
- Unifying Concepts and Processes Standard: Evidence, models and explanation.
- Physical Science Standard: Motions and forces.

Summary
Students will determine the flight characteristics of a paper boomerang by studying the flight variables associated with lift and drag.

Objectives
Students will:

- Determine the effects of changing airfoil shape on flight path
- Determine the throwing style for maximum flight
- Compare the flight variables that change when weight is added to an airfoil

Background
Each airfoil of the boomerang has a leading and trailing edge. Lift is generated over the entire top surface, but in proportion to the relative air velocity. As it spins, the wing at the top of the rotation has a greater air speed than the airfoil at the bottom of the rotation. These unequal forces result in two actions: the boomerang will shift from vertical to horizontal because of the greater force on the upper airfoil and precession causes the boomerang to move in a circular path. As the boomerang turns to the right or left (right-handed boomerangs travel and spin with counter-clockwise rotation and direction and left-handed boomerangs travel and spin with clockwise rotation and direction), the boomerang will move from vertical to horizontal until precession becomes minimal and the boomerang finishes its flight.

Materials

- tag board (card stock, file folder or paper plate)
- scissors
- masking tape
- safety glasses (optional)

Safety Instructions: *Use caution when flying the paper boomerangs. Create a single direction flight zone. Be sure that students stop flying their boomerangs when other students are retrieving boomerangs that have already landed.*

Procedure

A. Warm-up

1. Review the concept of the four forces of flight, emphasizing lift and drag.
2. Explain the flight of a boomerang and demonstrate how it flies. (Practice and refine your own technique before using this lesson with students.)
3. Explain the tuning process by bending the wings just a little (uniformly on each airfoil). Too much bend will cause greater drag and slow the rotation. Just a slight bend is needed.

B. Activity

1. Trace the master pattern on the tag board and cut it out.
2. Bend to tune for test flight.
3. Go to a large open indoor area (such as the gymnasium). Create a clear test area and allow students to fly the boomerangs one at a time.
4. To fly the boomerang, hold the boomerang vertically. Make a fist and hold one blade between your thumb and index finger. Bend your wrist back, so the boomerang nearly touches your forearm. Snap your wrist, spinning the boomerang straight out in front of you and releasing at eye level with your arm fully extended. The boomerang should be vertical, straight out from your body.
5. Change the bend of the airfoils and note the results.
6. Add a 4 cm strip of masking tape to one airfoil. Note the change in flight path.

Continue to add masking tape to another airfoil and note the change in flight path.

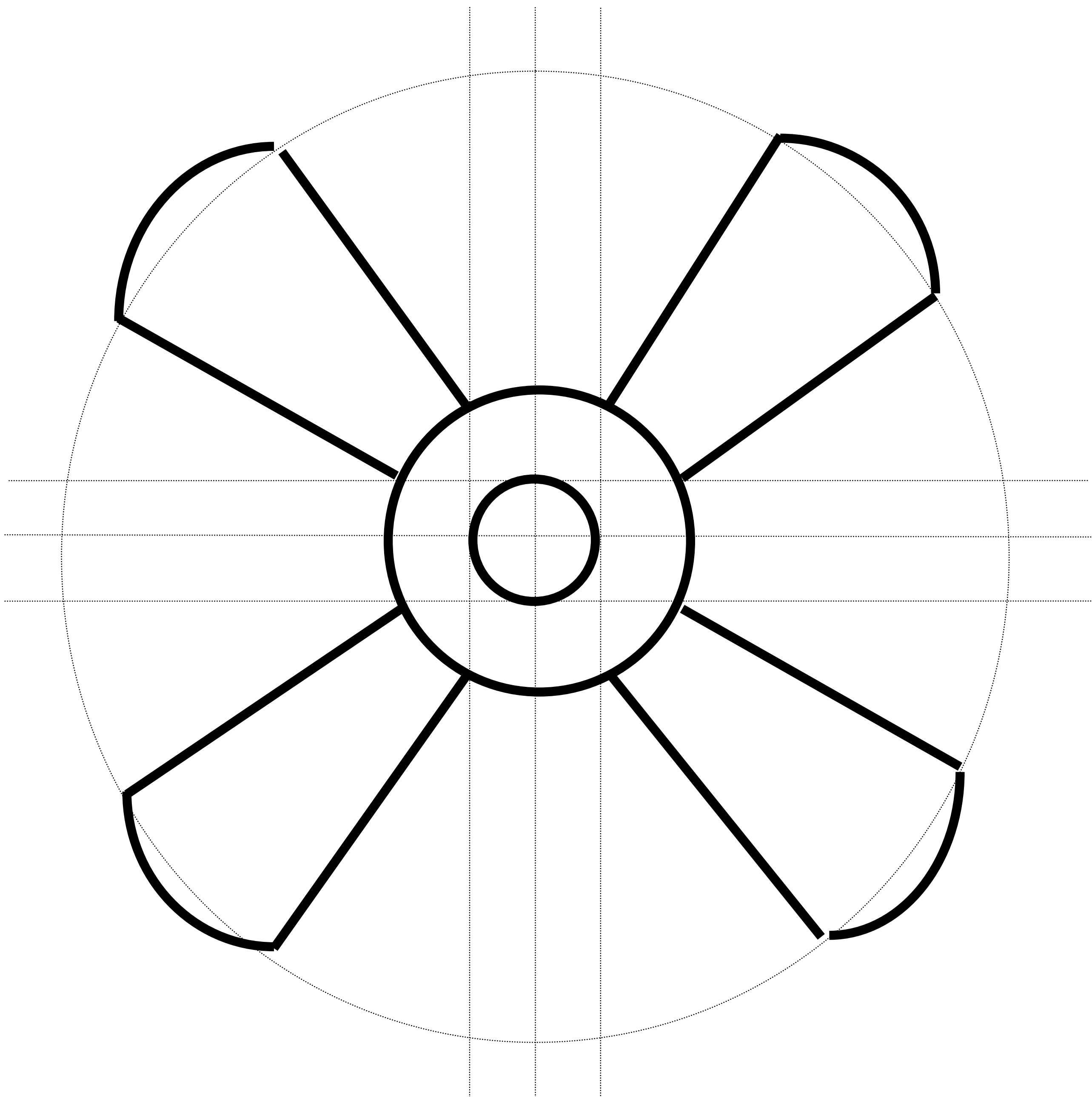
Assessment/Evaluation

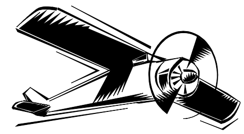
Students will report and discuss their findings.

Resources/References

Broadbent Boomerangs, 3204 38th St. NW., Canton OH 44718
U.S. Boomerang Association, P. O. Box 182, Delaware OH 43015

Boomerang Pattern





Milestones of Flight

Grade Level: 4-8 **Subject Area:** Science and Math

Time Required
Preparation: 1 hour
Activity: 1-2 hours

National Standards Correlation
Science (grades K-4)
- Earth and Space Science Standard: Objects in the sky.
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.

Science (grades 5-8)
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- History and Nature of Science Standard: History of science.
- History and Nature of Science Standard: Nature of science.

Math (grades 3-5)
- Number and Operations Standard: Compute fluently and make reasonable estimates.
- Representation Standard: Use representations to model and interpret physical, social, and mathematical phenomena.

Math (grades 6-8)
- Number and Operations Standard: Compute fluently and make reasonable estimates.
- Representation Standard: Use representation to model and interpret physical, social, and mathematical phenomena.

Summary
In this lesson, students will learn about some significant milestones in the history of flight. Using adding machine paper tape, students will create a time line to represent the chronological order of the milestones of flight.

Objectives
Students will:
- Study various resource materials on the history of flight
- Learn about significant events which occurred in the history of flight
- Create a time line of significant events in the history of flight (complete with illustrations)
- Laminate the time lines
- Display the time lines in the hallway at school for other students to see and enjoy

BACKGROUND - Milestones of Flight
1200-1300: People first attempted to fly by attaching wings to their bodies.
1290: Roger Bacon proposed a gas-filled balloon.
1500: Leonardo da Vinci made drawings of a parachute, helicopter, propeller and a flying machine with wings.
1650: Italian Francesco de Lana published the first design for an airship.
1783: First hot-air balloon flight by Jean F. Pilatre de Rozier and Marquis d'Arlandes in a Montgolfier balloon. First flight in a hydrogen-filled balloon. J.A.C. Charles and M. Robert flew 25 miles (40 km)from Paris, France in 2 hours.
1785: First crossing of the English Channel by air. John Jeffries and Jean-Pierre Blanchard flew in a hydrogen balloon from England to France.

1809: Sir George Cayley built and flew the first full-sized unmanned glider.

1842: William S. Henson patented a design for a steam-driven airplane that foreshadowed the modern monoplane.

1848: John Stringfellow made and flew a model airplane that is said to be the first power-driven machine to fly. It flew 120 feet at Chard, England.

1866: F.H. Wenham contributed valuable study on the laws of flight. Five years later Wenham designed the first wind-tunnel experiments.

1890: Clement Ader, a French engineer, achieved a distance of about 150 feet (46m) in a power-driven monoplane.

1894: Sir Hiram S. Maxim built a plane operated by steam engines, which lifted equipment and a crew of three into the air.

1891-1896: German inventor Otto Lilienthal made the first successful glider flights that are said to have inspired the Wright brothers.

1903: First engine-powered, heavier-than-air flight by the Wright brothers at Kitty Hawk, North Carolina, on December 17.

1909: The first successful airplane crossing of the English Channel by Louis Bleriot of France. The trip took thirty seven minutes.

1912: Glen Curtiss flew the first successful flying boat or seaplane.

1918: The first regular air mail delivery in the world was started by U.S. Army pilots on May 15.

1919: First nonstop airplane flight across the Atlantic was undertaken by British fliers John Alcock and A.W. Brown on June 14. The 1,936-mile (3,115km) trip took 16 hours, 12 minutes.

1924: The first round-the-world flight took place from April 5 to September 28. Two U.S. Army biplanes flew 26,345 miles (42,389 km) in 175 days.

1926: The first flight over the North Pole in an airplane was made on May 9 by Richard E. Byrd (navigator) and Floyd Bennett (pilot). The first airship flight over the North Pole took place from May 11 through May 14, with explorer Roald Amundsen, Umberto Nobile, and Lincoln Ellsworth on board.

1927: The first nonstop solo flight across the Atlantic in an airplane was flown by Charles A. Lindbergh on May 20 and 21. He flew 3,610 miles (5,806 km) in 33 hours 30 minutes, from Roosevelt Field, New York to Le Bourget Field, Paris.

1929: The first around-the-world flight by an airship was made by the Graf Zeppelin in 21 days, 8 hours, from August 8 to 29.

1932: The first woman to make a transatlantic solo flight was Amelia Earhart, who flew from Canada to Ireland on May 20 and 21 in 15 hours, 18 minutes.

1933: The first solo round-the-world airplane flight by Wiley Post took place from July 15 to 22, lasting 7 days, 18 hours, 49 minutes.

1939: The first jet-powered airplane was built by the Heinkel Company in Germany.

1940: The first successful flight of a single rotor helicopter took place on May 21, at Stratford, Connecticut, by Igor Sikorsky.

1947: The first flight faster than the speed of sound was made by U.S. Air Force Captain Charles Yeager in a rocket-powered Bell X-1.

1955: Turboprop airliners were put into service by the major United States airlines.

1959: Jet airliners began regularly scheduled flights in the United States on January 25.

1961: The first man to fly in outer space was Yuri A. Gagarin of Russia on April 12. On May 5 Alan B. Shepard, Jr. became the first American to make a space flight.

1962: On February 20, astronaut John H. Glenn, Jr. completed three orbits around the earth in a space flight that lasted nearly five hours.
1969: On July 20, Apollo 11 landed on the Moon, and Neil Armstrong became the first person to walk on the moon's surface.
1971: The first space station Salyut I, was launched into orbit.
1976: The world's first supersonic passenger aircraft began operating.
1981: The first space shuttle, Columbia, was launched on April 12 and returned to earth fifty-four hours later.
1981: The first flight of the Stealth aircraft, the Lockheed F-117A.
1986: January 28 the space shuttle Challenger exploded.
1994: Astronauts use jet packs to free-fly in space.

Materials

- adding machine tape
- ruler
- colored pencils/markers/crayons
- laminating machine
- double-sided tape

Procedure:

A. Warm-up

1. Show a video on the history of flight.
2. Have a class discussion about the historical importance of flight.

B. Activity

1. Measure and create a proportional scale to use for the time line (on adding machine paper tape).
2. Record significant events in the history of flight (on the adding machine paper tape).
3. Label and illustrate the time line.

C. Wrap-Up

1. Laminate time lines.
2. Display in hallway of school.
3. Create mathematics problems based on the time line dates.

Assessment/Evaluation

Students should be evaluated on class participation, their ability to follow directions and successful completion of project.

Resources/References

Platt, Richard. *Visual Timeline of Inventions*. London: Dorling Kindersley, 1994.
Scholastic Voyages of Discovery, *The Story of Flight*. New York: Scholastic Inc., 1995.